UG. 1947
20 No. 8

Instruments

IE MAGAZINE of MEASUREMENT and CONTROL

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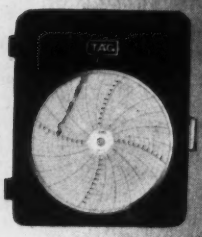
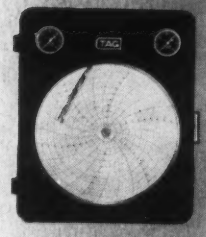
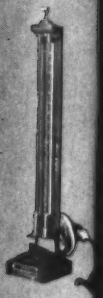
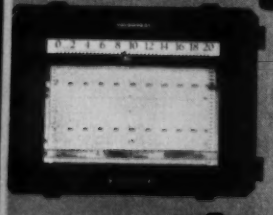
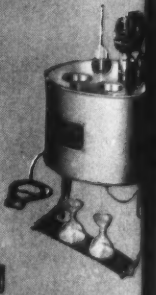
Yes, they'll all be there, ready for your inspection, just as TAG representatives are ready, as always, to help you with the correct application of dependable, accurate instruments in solving your temperature and pressure problems.

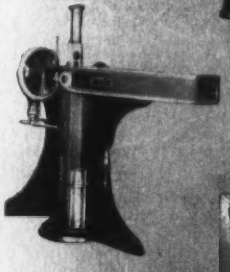


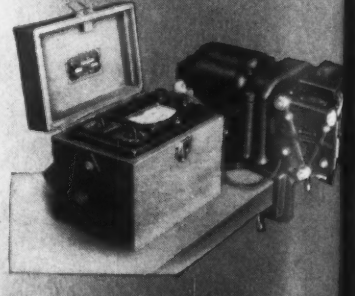


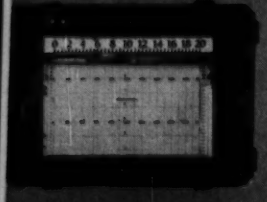












C. J. TAGLIABUE MFG. CO.

Instruments THE MAGAZINE OF Measurement and Control

M. F. BEHAR, Editor

The Scope of Science

AN INSPIRING "GUEST EDITORIAL"

INCREASING interest in science, in its facts and principles, its practical applications, and its bearings upon opinion, is undeniable. With this interest, there is growing up a new and enlarged meaning of the term.

By science is now meant the most accurate knowledge that can be obtained of the order of the universe by which man is surrounded, and of which he is a part. Science is now regarded as not applying to this or that class of objects, but to the whole of nature—as being, in fact, a method of the mind. What some call the progress of science, and others its encroachments, is undoubtedly the great fact of modern thought.

Many subjects once widely separated from the recognized sciences have been brought nearer to them. Intellect, feeling, human action, morals, all social relations—each has its basis of fact, which is the legitimate subject matter of scientific inquiry.

Those who consider that observatory watching, laboratory work, or the dredging of the sea for specimens to be classified, is all there is to science, make a serious mistake. Science truly means continuous intelligent observation of the characters of men as well as of the characters of insects. It means the analysis of mind as well as chemical substances. It means the scrutiny of evidence in regard to political theories as inexorable as that applied to theories of comets. It means the tracing of cause and effect in the sequences of human conduct as well as in the sequences of atmospheric changes.

Telegraphs, steam engines, and the thousands of devices to which science has led, are great things. But what, after all, is their value compared with the emancipation of the human spirit?

E. L. YOUMANS

These lines, which might have been written today, are digested from the editor's introduction to the first issue of *Popular Science Monthly*, May 1872. About to celebrate its own twentieth anniversary, *Instruments* salutes *PSM* on its Seventy-fifth Anniversary. —MFB

Copies *Will* Be Mailed Flat

IT was not on purpose that recent issues of *Instruments* have been mailed in tight wrappers, wrote Mr. Rimbach, our President and Business Manager, to complaining subscribers: it was because there were no envelopes to be had. He has just asked us to announce that, at last, an envelope company has accepted his order.

The CHRONOTRON

IT has been a pleasure, now and then, to report that scientists have attained one more decimal place in accuracy—or at least in sensitivity. The last time was in April 1942, when this page reported that frequency standards are checked at Bell Labs to one part in ten billion.* This time it's about TIME (excuse the unoriginal pun): Last year in *The Physical Review* Dr. S. H. Neddermeyer ran a brief preliminary announcement of his Chronotron, an apparatus capable of measuring extremely short time intervals. Now, in the July *Review of Scientific Instruments*, he and three co-authors give a detailed description of the Chronotron and they report that the precision is better than a "jiffy." The jiffy is the time it takes for light to travel one centimeter in vacuum; it is equivalent to 0.000,000,000,033... second.

*And now a commercially-available frequency standard, announced on the first page of this month's New Instruments Department, is guaranteed accurate to one part in a hundred million.

Last Call for Conference!

NOW is the time—and there is barely time — to make final plans to attend the ISA's Second National Conference and Exhibit. See the Program Supplement. All technical sessions will be outstanding. All prominent instrument firms will exhibit their new post-war devices. All signs point to a memorable occasion.

Instrumentation For Flight Testing AIRPLANES

By W. G. BROMBACHER, Chief, Mechanical Instruments Section, National Bureau of Standards, Washington

SUMMARY

The choice of instruments for flight testing airplanes is limited by difficulties in procurement, the necessity for ease and simplicity of installation and the requirement for obtaining simultaneous data on a large number of variables. At present the most practical solution is to photograph, insofar as possible, available indicating instruments which in a large number of cases are of the remote-indicating type. Electrical and mechanical (stylus type) recorders as now available are of limited application. New developments of remote indicators where feasible should be of the electrical type, particularly if dynamic recording may upon occasion be required. The instrument elements now available or possible of development are listed.

Introduction

It is realized that flight test instrumentation is only a means to an end, the securing of adequate and accurate data on the performance of aircraft. In this survey, however, the emphasis will be on the instruments and the associated problems, to the relative neglect of the ends for which they are needed. To carry out the above object the present status of flight test instrumentation in this country is presented insofar as data are available. The discussion of instruments in detail is largely confined to those needed in the acceptance testing of airplanes Instruments peculiar to structural flight tests, flight test of airships, gliders and helicopters, and to telemetering, are not covered.

The coöperation of the Airborne Equipment Division, and particularly of Cdr. S. S. Sherby USN of Flight Test, Naval Air Test Center, both of the Bureau of Aeronautics, Navy Department, is gratefully acknowledged.

Specifications

The specifications of an ideal flight test system are given below. These specifications must be kept in mind when a choice of instrumentation is possible, since the nearness of approach to their fulfillment is a measure of the flexibility and ease with which the instrumentation is accomplished,

(a) Primarily the required data should be recorded automatically at any rate, slow or fast, as may be necessary. Secondarily, indication of any particular phenomenon should be available to the pilot when desired.

(b) As a corollary to requirement (a), the instrument elements should be of a design to permit recording of their indications on the selected type of recorder or recorders and, alternately, in the cases desired, should permit connection to a remote indicator.

(c) Instrument elements should be designed insofar as possible to permit their installation in all types of aircraft.

(d) Instrument elements and recorders should be easy to install and maintain in aircraft, and should be compact and light in weight.

(e) The output performance (accuracy, sensitivity, low lag, etc.) of each element of the system should be adequate under the conditions of temperature, vibration, etc., encountered in aircraft.

(f) The method of recording must be such that associated data can be easily synchronized.

(g) The recording system should be flexible so that the measurements may be made in groups as large or small as desired.

(h) The method of recording should minimize the time and effort required to work up the recorded data into usable form.

(i) The adjustments to be made by the pilot or observers in securing proper functioning of the instruments should be minimized.

(j) The power supply required for operating the instruments should be uniform insofar as possible.

Personnel

While much of the flight test instrumentation is of a routine character, there is always a fringe of additional data required and the difficulties of obtaining even routine data vary from aircraft to aircraft. A variety of new and special instruments are ever required as aircraft speeds and altitudes increase and new forms of aircraft (as jet-powered aircraft and helicopters) are developed. In many cases, efforts to purchase satisfactory instruments will fail by reason of procurement difficulties outlined in the section on "Procurement." Therefore some types of instruments will have to be constructed or—more frequently—existing instruments modified and, to a lesser extent, new instruments will have to be designed by the flight test agency.

To carry on flight tests effectively it is thus essential to have a well integrated instrument staff. This will include personnel for installation and maintenance, and instrument engineers capable of designing and modifying instruments. Shop facilities must be provided for them. An important part of maintenance is the considerable load of testing required to assure dependable instrument performance. In view of the present difficulty of obtaining adequate engineering personnel, qualified outside organizations,when and where available, may have to be drawn upon as a source for the development and construction of special instruments. Someone in the organization should keep informed on flight test instrument developments by others with the view of taking advantage of improvements in instrumentation and of the possibilities of outside procurement. For continuing success this activity must be pursued steadily and thoroughly.

Procurement

Instrument firms in general find the market too small to warrant much development solely in the field of flight test instruments. Few competent organizations are interested even if the cost of development is met by the customer. This presents a real difficulty in meeting new instrument requirements in flight testing. Since fundamental instrument developments can be undertaken only in cases of extreme necessity and then only in isolated instances, the flight test engineer is forced to adapt, whenever and however possible, instruments and methods which were developed mainly for other purposes. Photographing groups of indicators in flight testing is an example of this situation. Here the indicators were largely already-available service instruments which had an exceedingly good performance; commercial cameras needed little modification to make them serviceable. Although smaller-diameter indicators are desirable for small aircraft, nothing much will be done until a commercial supply is available, and this

will not be available unless needed for a wider application.

Only in the cases of great necessity is development work on indicating and recording instruments undertaken, and then usually not by the instrument firms, but by the flight test units of the aircraft companies or of the Navy and Army. Considerable progress in design and adaptation was made under the unusual circumstances existing during the war years, but not much of the instrumentation is generally available because the individual instruments were designed and constructed for local use only.

So the general situation is that needed instruments uniquely required cannot be obtained commercially and that, by and large, flight test units must develop their own instruments and techniques with the help of information which filters out from similar units in the form of publications or as a result of personal contacts.

A forward step would be some arrangement whereby flight test organizations interchange design information on instruments commonly required for the purpose of avoiding duplication of work in design and procurement. Many diverse designs of instruments to measure the same variable are available from which the best can be selected for general use. In some cases procurement can be simplified for all concerned by arranging to secure the instrument from a common source of supply which could be located more easily with the prospect of a larger market. Examples of instruments of diverse designs which could be standardized on a national scale are those for accurately measuring yaw, free air temperature, Pitot and static pressure, and perhaps control forces and positions. A committee formed under the auspices of the Army and Navy, a national engineering society, or perhaps the NACA, might effect the necessary arrangements for the interchange.

Standardization of many flight test instruments seems feasible, especially where the same methods of measurement are used by most of the testing agencies. The standardization must be concentrated on individual instruments and not on methods of measurements. The latter must be kept open to change. Thus, for example, a satisfactory design of vane type yawmeter might be accepted as a standard, but it would be undesirable to standardize on this method of measuring yaw and thus—inferentially at least—tend to discourage the development of better methods.

Obtaining an adequate supply of the special instruments of established design is always a problem. In most cases they cannot be secured from stock anywhere, but must be made upon order, which means a big time lag between the order and the delivery. Foresight is required in locating a source of supply, placing orders in the cases where that is possible, in order to avoid acute shortages and consequent delays and excessive installation labor in flight testing.

TABLE I—METHODS OF RECORDING ON AIRCRAFT

Available or Design Established:

1. Photo panel recorder.
2. Individual photo recorders.
3. Mechanical recorder, stylus type.
4. Dynamic type, oscillograph, galvanometer type with or without amplifiers; application limited but growing.
5. Brown electrical recorder, sequence type, application limited. Modified by Minneapolis-Honeywell for their own use in flight testing (Reference 25).
6. Douglas electrical recorder, rapid-sequence type, application and accuracy limited.

Requiring development:

7. Electrical recorder equivalent to No. 1 above in accuracy, reliability and compactness, either printing data in the form of numbers or producing them in the form of curves. (Fast-sequence recorders [Keinath, reference 24] might be acceptable.)

Installation

Instruments for flight testing must be installed, almost in their entirety, as additional to the usual complement of instruments on the aircraft. In practically all cases, the point at which the measurement is to be made is remote from the point of recording, or other circumstances dictate a remote-indicating design. Ease of installation of all parts of the instrumentation system is therefore an important item in choosing the type of system. Installing electrical leads from the various measuring elements to the indicators or recorders is considerably less trouble than running lines of tubing, as is normally required for the host of pressure-measuring instruments needed, or mechanical connectors, if that were even considered. In some cases, however, as in measuring static pressure (and perhaps Pitot-static pressure) electrical transmission may not be immediately feasible owing to difficulty in obtaining sufficient sensitivity and perhaps accuracy.

Bulky recording equipment is difficult or impossible to install in the smaller size aircraft, for which an obvious solution is smaller indicators in the group photo recorder,—or which is not so satisfactory—tests made piecemeal with smaller recorders or remote indicators observed by the pilot.

One procedure which will save much time in flight testing by the military flight test units when feasible is that first proposed by the British.[12] This is to have the aircraft contractor install the various electrical lines and the measuring elements needed for flight testing in the aircraft during assembly of the aircraft. If the contractor and the testing agency used measuring elements of the same design, this procedure would effect a real saving in effort. It appears that instrument installation by the contractor is not practal in airplanes to be given type tests, which are normally selected only after complete assembly.

Methods of Recording

The various methods of instrument recording on aircraft are listed in Table I. Of these the photo panel recorder for general use, the Brown "Electronik" recorder (electrical) for engine temperature surveys, and dynamic recorders (oscillographs) for fast-changing phenomena are in common use by all aircraft organizations except that individual recorders instead of the photo panel recorder are largely used by the NACA.

Photo Panel Recorder

In this method of recording, indicating instruments measuring the various conditions are grouped on a panel and photographed at desired time intervals. This method has the primary advantage of permitting the use of service instruments in large measure, immediately relieving the difficulties of procurement, since instruments of satisfactory accuracy and sensitivity and relatively low cost are available. The accessory equipment, principally a camera and a rate-of-exposure control, are available. The necessity of adding many measurements to the program and the limited space of the smaller aircraft is making necessary the use of smaller sized indicators when procurable. The individual instrument element systems will be discussed in a later section.

The method works well in practice; relatively the equipment is not difficult to install, service or maintain. The rate of making photographic exposures is adjustable in flight by an intervalometer within quite wide limits so that considerable selection of the rate of taking data is possible. For obtaining data on fast-changing phenomena the response of the indicators is in general too slow, or the rate of taking pictures is too slow; so that other means must be used as discussed below under "Dynamic Recorders." However, measuring elements of the electrical type should be chosen when possible in the cases where dynamic recording may be needed so as to permit their use as desired with either photo panel recording or with the dynamic recording now in use.

One drawback is the considerable labor involved in reading the data from the film and putting them into usable

form. Also, during flight the pilot or observer must control the taking of data and their rate by suitable apparatus, but this sort of control would also be necessary in most of the other systems.

Individual Recorders

(a) *Optical type.* A system of individual recorders of the optical type is quite feasible and in fact is almost exclusively used by the NACA laboratories. The final element, whether a pressure capsule or electrical indicator or gyroscope, is equipped with a mirror which rotates as the element deflects. A light beam reflected by the mirror onto a film or photographic paper produces the record. The chart is moved as required by a clockwork or an electric motor. A continuous curve is obtained. An intervalometer marks time intervals on the chart for use in synchronization.

In routine flight testing, procurement and maintenance problems are simpler and cheaper when photographing the dials of instruments largely available than with individual optical recorders where the measuring elements are not commercially available. However, with the trend toward electrical measuring elements and the growing necessity of dynamic measurement, the use of individual optical recorders of the galvanometer type is becoming common. The recent commercial availability of these recording units in compact form provides a suitable recording means for many of the conditions now most conveniently measured electrically. These recorders are inadequate for general use in a number of details but are useful in specific tests. Further development if directed to flight test requirements will broaden their application.

The NACA system was originally developed for measuring pressures. For this purpose, photographing commonly-available indicators installed on a common panel still seems preferable—particularly from the view of easier procurement, possibly less installation and servicing labor and on the whole greater sensitivity and probably accuracy. It may be mentioned that there is real difficulty in obtaining adequate sensitivity in measuring free air pressure and perhaps indicated airspeed from an optical recorder of either the mechanical or electrical type.

(b) *Mechanical type.* These are defined as recorders in which the sensitive element in the recorder transmits its motion mechanically to pen or stylus which records on a chart driven by a clockwork or motor. The recorder has little promise of being useful for measuring all the phenomena in flight testing since so many of them are most easily measured electrically. The accuracy is also below permissable limits for many applications. However it is of value for use in selected cases permitting tests to be made with a minimum of installation and subsequent processing labor. Examples are the barograph, airspeed recorder and *VGAT* recorder.

Of another class is the *V-G* recorder which is widely used because of its convenience. Here a pressure element connected to a Pitot-static tube and an accelerometer element are combined into one mechanism with a stylus recording air speed against acceleration on a smoked glass plate. With instruments now available separate records of *V* and *G* can be obtained which are inherently more accurate, but at greater expense.

Dynamic Recorders

To record fast-changing phenomena which are out of the frequency range of the ordinary recorder, present practice is to use an oscillograph. Examples of these phenomena are acceleration and vibrations. The system commonly used is based on a electrical output from the measuring element, which is amplified or not as necessary and is passed through a galvanometer. A mirror on the galvanometer element rotates a light beam as it deflects to obtain a record photographed in the form of a continuous curve. These oscillographs are supplied commercially with multiple channels, usually up to 24, all recording the same chart which is motor-driven at any desired speed. An alternative method possible or necessary in some cases, although frequently used, is a cathode-ray oscilloscope, the indications of which may be photographed.

An important point to notice is that the input to the recorder must be electrical in nature, which requires for simplicity that the output of the measuring element also be electrical.

Electrical Recorders

The discussion is limited here to electrical recorders of the type producing a record by pen or stylus.

Electrical recorders, usually the Brown and to a lesser extent the Leeds & Northrup, are widely used to record cylinder-head temperatures as measured by thermocouples. Individual readings are recorded in instruments now available by ink (other means are alternative) at the time intervals of 1½ to 2 seconds. By switching arrangements a single recorder can record in sequence on a 10″ chart more than 100

TABLE II—LIST OF TYPES OF FLIGHT TEST MEASURING ELEMENTS OR INSTRUMENTS

Types of Single-element Instruments	*Measurements Usually Made*
(a) Absolute pressure gages	Pressure altitude, manifold pressure, carburetor deck pressure.
(b) Differential pressure gages	Indicated airspeed, exhaust back pressure, baffle pressure drop, fuel and oil pressure, suction, rate of climb (direct indication), engine torque, gas flow.
(c) Resistance thermometer, unbalanced bridge type	Free air temperature, oil or coolant temperature, carburetor air temperature.
(d) Thermocouple thermometer	Cylinder-head temperature, tail pipe temperature.
(e) Timepieces	Timing and synchronization of events.
(f) Voltage-dividing resistor transmitter, d-c. Selsyn transmitter, Autosyn transmitter, Magnesyn transmitter	Control forces, control position, angle of attack, yaw, cowl-flap position, oil or intercooler shutter position, oil, fuel or manifold pressure, fuel flow.
(g) Electric tachometer, ac. synchronous	Engine speed, turbosupercharger speed.
(h) Static tube	Air speed, free air pressure, rate of climb (direct indication), *V-G* record.
(i) Pitot tube	Air speed, *V-G* record, jet velocity, gas velocity at any point, water speed.
(j) Electric resistance strain gage transmitter	Control forces, control position, differential pressure, absolute pressures, accelerometers.
(k) Reluctance transmitter Capacity transmitter	Limited utility except for accelerometers because amplifier or other auxiliary apparatus is usually required.
(l) Gyroscopic instruments	Turn and rate of turn, roll and rate of roll, pitch and rate of pitch.
(m) Accelerometers and Vibrometers	Acceleration of aircraft and of parts, vibration, frequency and amplitude.
(n) Intervalometer	Control rate of camera operation, synchronization of recorded data.
(o) Carbon monoxide indicator	Carbon monoxide in aircraft.
(p) Wind speed and direction indicator	Wind velocity during take-off tests.
(q) Differential pressure recorder	Special purposes.
(r) Barographs	Free air pressure.
(s) Statoscope	Constancy of air pressure.
(t) Camera	For take-off tests, photo panels, etc.
Types of Compound Elements	*Measurement Made*
(a) Pressure ratio	Mach number.
(b) Differential pressure-acceleration	V-G record.
(c) Pressure-temperature ratio	True air speed

TABLE III—LIST OF FLIGHT TEST INSTRUMENT ELEMENTS

S=Used on service aircraft or can be obtained commercailly without difficulty.
C=Customary practice.
A=Alternative and available.
X=Alternative experimental, at present unavailable or performance inadequate.
L=Limited application, procurement special.
D=Desirable development but not actively underway.

Condition Measured	*Use*	*Instrumentation*	*Recording Method*
1. Pressure Altitude (Free Air Pressure)	CS	(a) Sensitive altimeter connected to remote static tube.	Photo Panel
	X	(b) Aneroid barometer connected to remote static tube.	
	X	(c) Sensitive altimeter connected close to static tube;	
		(a) d-c. Selsyn or voltage-dividing resistor transmitting to remote indicator.	Photo Panel
		(b) v-d. resistor to recorder.	Electrical or Oscillograph
	X	(d) Aneroid element connected close to static tube; electric strain gage transmitting	
		(a) to indicator.	Photo Panel
		(b) to oscillograph.	Oscillograph
	X	(e) Aneroid element with follow-up system, using capacitance pick-up or electrical contacts; the angular motion of a two-phase motor, proportional to pressure change operates an Autosyn transmitter.	
	L	(f) Barograph connected to static tube.	Clock driven drum
	L	(g) Aneroid element connected to remote static tube with optical lever indication (NACA).	Photo, on rotating drum

The accuracy of element (a) is about 30 ft. or ¼%, whichever is greater; of element (b) 0.01 in. of mercury; and of element (f) 0.03 in. of mercury.

On element (c) not enough design experience is available to estimate the obtainable accuracy, but obtaining better than 30 feet will be difficult, though perhaps unnecessary in many applications.

Accuracy obtainable with element (d) is estimated as within about 2% of the pressure change, which is a severe limitation on the general use of this method, but perhaps adequate for many applications.

Element (e) has been developed (Minneapolis-Honeywell), but its utility in flight testing aircraft remains to be determined.

2. Calibrated Air Speed	CS	(a) Differential pressure gage, sensitive or non-sensitive type, connected to remote Pilot-static tube.	Photo Panel
	X	(b) Differential pressure gage connected close to Pilot-static tube;	
		(a) d-c. Selsyn, Autosyn, or voltage-dividing resistor to remote indicator.	Photo Panel
		(b) v-d. resistor transmitting to recorder.	Electrical or Oscillograph
	X	(c) Pressure element connected close to Pitot-static tube; electric strain gage transmitting.	
		(a) to indicator.	Photo Panel
		(b) to oscillograph.	Oscillograph
	L	(d) Differential pressure recorder connected to Pitot-static tube.	Clock-driven drum
	L	(e) Pressure element connected to remote Pitot-static tube with optical lever indication (NACA).	Photo, on rotating drum

The accuracy of the indicator (a) is about one knot. This can be more nearly obtained from the indicators available than from any of the other four arrangements listed. Of these the electric resistance strain gage type will have with present techniques an inferior accuracy, estimated at 2%. However, an electrical transmitter of some form, even of less accuracy than (a), is desirable for use with dynamic recorders.

3. True Air Speed	C	(a) Computed from air pressure and temperature data.	
	XS	(b) Indicator of pressure-temperature ratio connected to remote Pitot-static tube and air temperature element.	Photo Panel
	X	(c) Rotating vane types.	Photo Panel
	D	(d) Resistance thermometer, two elements with different airspeed effects, milliammeter indicates difference in effects, proportional to true airspeed squared.	Photo Panel

Element (b) is available but the accuracy is too low except when rough values of true air speed are adequate. No direct indicating instrument has at present much promise of successful development for precise flight test use.

Continued on next page

temperatures if desired. This means that the temperature at each point is measured at 3-minute intervals or less, depending upon the number of measuring points. This performance is acceptable only when the readings are desired under essentially equilibrium conditions.

The rate of temperature recording by these electrical recorders is too slow in many cases. This could be met by limiting the number of temperature measurements recorded by a single recorder and adding recorders for the other measurements but this solution is not always possible, feasible nor desirable owing to the bulk of the recorders and the necessity of synchronization. To speed up the recording, Keinath[24] has proposed recorders for various purposes in which the pen and a contactor on a voltage-dividing resistor move together continuously, but the pen prints on the Teledeltos paper only when the electrical bridge or potentiometer circuit is in balance.

Blackmon[22] has designed and constructed a similar recorder except that at the electrical balance point a light flashes and a picture is taken of an indicating drum moving in synchronism with the contactor. An automatic switching arrangement permits successive indication of temperature at any reasonable number of points. The speed of recording is ten readings per second, which is also the present limit of the Keinath recorder. This advance in technique will prove valuable in engine temperature surveys.

Although not now available, the possibilities of an electrical recorder should be considered as an alternative for the photo panel recorder because the electrical recorder can produce a record in the more acceptable form of curves, thus giving a complete record and eliminating some of the processing of data. Preferably the recorder should not require an electronic amplifyer because of the added weight and labor of servicing such equipment. Ideally, a continuous synchronous record of many of the conditions being measured is required, but this procedure leads essentially to individual electric recorders, the bulk of which is prohibitive. Recording the variables in sequence as is now done for cylinder-head temperatures is inadequate because of the lack of recording speed and if only one recorder is used, because of the multiplicity of traces. A solution may be possible where two or more recorders of the fast-cycling type (Keinath) are used. The record would be made on strip chart driven at will at any selected rate. For variables requiring considerable sensitivity such as air speed, air pressure and air temperature, one recorder would be equipped with a single pen, the other recorders for variables requiring less sensitivity, with two or three pens. By grouping the instruments and with the use of schemes for distinguishing traces, probably six or more conditions could be recorded by

one pen. The scheme seems feasible, but the accuracy obtainable in the designs now projected seems inadequate for many conditions; also the development of recorders specially for flight test use may be difficult.

The Minneapolis-Honeywell Co.[28] has recently announced that they have developed a recorder for their own flight testing which records simultaneously air speed, altitude, control positions, direction and power conditions. It is understood to be a modification of the Brown recorder, but no details are available.

Telemetering

It is obvious that telemetering, that is, recording flight test data on the ground, will in general become more and more necessary with the advent of guided aircraft and missiles. Systems for aircraft use have been developed by Vultee,[13] Cornell Aeronautical Laboratory, and Fairchild.[26] Undoubtedly other organizations are developing or are using such systems. Telemetering is outside of the limits of this survey but it should be noted that in all systems the measuring elements must deliver an electrical output. While standardization of measuring elements in flight testing is not to be immediately expected, yet considerable indirect progress is possible if the flight test instrument system be based, where a choice is possible, on measuring elements having an electrical output. Adaptation should not then be too difficult and at any rate the experience of the personnel would be in the right direction.

Individual Instruments or Measuring Elements

The elements to be discussed include both the transmitter and receiver of remote-indicating instruments, but only the transmitter or measuring element when dynamic or electric recorders are used. The discussion is largely restricted to the variables measured in the air. In general, the usually-installed service instruments, including the autopilot, are used by the pilot as controls of the conditions desired while obtaining flight test data. Reference 23 indicates the usefulness of the autopilot in some tests. However, since this instrumentation is always available without special effort to flight test units, no discussion is necessary except perhaps on special items.

Table II is a list of the types of instruments currently required or used in flight testing. The measurement for which each type is or might be used is given.

Table III is a list of the phenomena usually measured, the instruments available or in prospect for the measurement, and the method of recording for which they are suitable.

Table IV is essentially a reclassification of Table III to show the availabil-

TABLE III *(Continued)*

Condition Measured	*Use*	*Instrumentation*	*Recording Method*
4. Mach Number	CS	(a) Indicator of ratio, Pitot to static pressure, connected to a remote Pitot-static tube.	Photo Pan
	D	(b) Indicator of pressure ratio connected close to Pitot-static tube;	
		(a) d-c. Selsyn or v-d. resistor to remote indicator,	Photo Pan
		(b) v-d. resistor transmitting to recorder.	Electrical Oscillogra
		Element (a) has an accuracy of about 0.02 Mach number. The power available coupled with the low accuracy, now sufficient, makes element (b) practical, when the need for it becomes urgent.	
5. Pitot-static Pressure	C	(a) Total head tube.	
	C	(b) Swiveling static tube.	
	X	(c) Swiveling Pitot-static tube (Martin).	
		Tubes (a) and (b) form a combination now in general use.	
		Tube (c) is a unit which may be preferable because procurement and installation are simplified somewhat.	
5A. Calibration-Airspeed Indicator	C	(a) Time over speed course measured by stop watch; airspeed recorder optional.	
(Service installation or installation of 5(a) and (b) or (c).)	X	(b) As above except that the time is measured on the ground by devices which may be considered experimental.	
	X	(c) Radar.	
	L	(d) Suspended Pitot-static tube with indicator in the aircraft.	
	X	(e) Suspended Pitot-static tube and pressure element; remote indication with Telegon, Selsyn or v-d. resistor.	
		Method (a) is fundamental, but calibration by alongside flying is a general practice. Methods (b) and (e) have not worked out. Occasional tests are made with element (d), especially at stalling.	
		It is possible that radar can be used to measure ground speed which can be corrected to indicated airspeed if the static pressure and air temperature are also measured. Only advantage is that data could be obtained at high altitudes. It has been used by the NACA to determine altimeter lag.	
5(b) Calibration-Static Tube	C	(a) Aircraft flown at the level of a tower; aircraft altimeter and tower altimeter readings compared.	
	C	(b) Double sighting stand; altimeter and thermometer at ground level.	
	C	(c) Suspended static tube with indicator on aircraft.	
		Convenience or necessity dictates which one of these methods is used. Method (a) seems preferred in view of its comparative simplicity. Method (c) is useful at low speeds and for high altitude calibrations; safe designs for speeds much above about 300 mph are not available.	
		Calibrations 5(a) and 5(b) are often combined. Actually the principal source of error in special pitot-static installations is in the measurement of static pressure, therefore calibration of the static tube is often all that is necessary.	
6. Gas Velocity (Jets)	C	Pitot-static tube traverse; differential pressure gage indicators.	Photo Panel
		Pressure "Rakes" or "Combs" are commonly used; other types of pressure indicators than listed above are possible but simplicity and availability seem to make them the best choice, unless or until dynamic measurements are needed.	
7. Free Air Temperature		Resistance thermometer unbalanced bridge,	
	C	(a) Milliammeter indicator or ratio type indicator.	Photo Panel
	X	(b) To recorder direct.	Electrical
	X	(c) As above, except element indicates stagnation temperature.	Photo Panel or Electrical
	X	(d) Resistance thermometer two elements, indicates on milliammeter free from air speed error. (Rockefeller)	Photo Panel or Electrical
		It seems advisable that where method (a) is used a change be made to either methods (c) or (d). Progress has been made on the development of both; Lockheed has a design which meets item (c). The Rockefeller design (d) requires redesign if an indicator is used, but the elements as now designed are ready for use with an electrical recorder.	
		A ratio type indicator with 270° pointer motion is needed for elements (a) and (c). Under development by manufacturers.	

Condition Measured	*Use*	*Instrumentation*	*Recording Method*
8. Liquid and Gas Temperature (Oil or coolant, carburetor air, cabin, etc.)	CS	Resistance thermometer, (a) Ratio type indicator.	Photo Panel
	X	(b) To recorder direct.	Electrical
	L	Thermocouple thermometer. (a) Voltmeter indicator.	Photo Panel
		(b) To recorder direct.	Electrical (Brown)
Securing adequate accuracy in measuring liquid or gas temperatures in the medium temperature range offers no serious instrumental difficulty. Measuring high gas temperatures, as in jets, is difficult owing to the limitations of thermocouples to about 1000°C. Other methods remain to be developed.			
9. Metal Temperature (Engine cylinders, tail pipe, etc.)	C	Thermocouple connected to recorder.	Electrical (Brown)
Thermocouples are limited to about 1000°C., possibly high enough at present. Further development, and perhaps invention, needed.			
10. Rate of Climb	C	Computed from pressure altitude and air temperature data against time.	
	LS	Rate-of-climb indicator connected to remote static tube.	Photo Panel
Rate-of-climb meter useful only in tests where rough values of rate of climb are tolerable.			
11. Differential Pressures (Above about 5 lbs./in.²) (Fuel, oil, hydraulic, suction gage, etc.)	CS	Pressure gage, Bourdon type, connected to pressure point by tubing.	Photo Panel
	CS*	Bourdon tube or metal bellows and Autosyn or d-c. Selsyn transmitting to indicator.	Photo Panel
	X	Bourdon tube or equivalent and electrical resistance strain gage, transmitting to (a) Microammeter.	Photo Panel
		(b) Recorder.	Electrical
*Fuel and oil pressure gages only. Other applications X. Bourdon tubes are difficult to use with electric strain gage. A bellows or diaphragm pressure element may be necessary in order to secure this type of transmitter. Ranges of these gages extend easily to 5000 lbs./in.².			
12. Differential Pressures (Below about 5 lbs./in.²) (Misc. applications)	C	Diaphragm type pressure gage, connected to pressure point by tubing.	Photo Panel
	X	Diaphragm capsule with electrical resistance strain gage transmitting to (a) Microammeter.	Photo Panel
		(b) Recorder.	Electrical
The lower range limit of these gages is about 4 inches of water. The Bourdon tube does not lend itself to ranges much below 5 lbs./in.².			
13. Manifold Pressure and Carburetor Deck Pressure	CS	Aneroid type pressure gage, connected to pressure point by tubing.	Photo Panel
	CS	Aneroid capsule with d-c. Selsyn or Autosyn, connected to remote indicator.	Photo Panel
	X	Aneroid capsule with electrical resistance strain gage, connected to remote (a) Microammeter.	Photo Panel
		(b) Recorder.	Electrical
These instruments are essentially aneroid barometers of relatively low sensitivity, with a present range from 10 to 75 inches of mercury. A sensitive non-electrical type is also available.			
14. Yaw and Angle of Attack	C	Vane in airstream, mechanically connected to either a d-c. Selsyn, Magnesyn, Autosyn or v-d. resistor; appropriate remote indicator.	Photo Panel
A number of types are in use by various organizations, varying only in the design details of geometry and transmitting means. Few data are available on whether performance is satisfactory at subsonic speeds.			
14A. Flight Calibration of Angle-of-Attack Indicator	C	Pendulum type inclinometer with electrical resistance strain gage connected to remote microammeter.	Photo Panel
Extreme sensitivity required from inclinometer in flight testing the angle-of-attack indicator.			

Continued on next page

ity of instruments for the various methods of recording.

Not all of the measurements listed in Table III are made on all aircraft and, further, those made are not in general conveniently or even possibly made simultaneously. Further, the tests must be made piecemeal in the smaller aircraft where the recording equipment needed for all measurements cannot be installed as a unit. Also, in some cases, the observation of remote-indicating instruments is sufficient to obtain the data desired, which is an advantage since the expense and work of installing recording apparatus is thus avoided.

Certain quantities desired require computation from a number of measured phenomena because no convenient or completely satisfactory means of making direct measurements are available. Examples are: (a) rate of climb from simultaneous values of pressure altitude and air temperatures, (b) true air speed from calibrated air speed and free air temperature, (c) air density, and (d) thrust of jet engines.

It is necessary in some cases to have instruments of various designs available to measure a given phenomenon. This gives a choice of the simplest means necessary to obtain the requisite accuracy, with particular reference to ease of installation and processing of data. Compound instruments, such as the V-G recorder, Mach meter and true airspeed meter, have a low accuracy compared with instruments making the individual measurements involved, yet in cases where their accuracy is adequate, their use is preferable for the reasons given above.

In most tests the parameters of air pressure, free air temperature and air speed must be observed or, preferably, recorded. Other observations are also associated so that they must be obtained simultaneously in order to be of value, of which many of the powerplant performance conditions are conspicuous examples.

It is the practice to house a number of powerplant instruments in the same case, with concentric pointers and a common dial, examples of which are the dual electric tachometer and dual electric fuel or oil pressure gages, or with essentially separate dials as in the engine gage unit. In photo-panel recording the use of these instruments is a big help in keeping the size of the photo panel down.

In measuring elements where a strain is produced, the use of electrical resistance strain gages is coming into high favor. These are convenient to use and in many applications are indispensable. One of the possible disadvantages is that the output is somewhat small for measurement, without amplification, by an indicator, which is required when a photo-panel recorder is to be used, or an indicator is to be observed. However, microammeters are available of small

size which just do the job in some cases. Where the power output is inadequate, amplification must be interposed between the indicator and measuring element, but this is avoided when possible because it adds to the maintenance and installation work and increases the chance of failure to secure flight data in any given test.

The construction of most measuring elements of the strain gage type is simple and their application is within the capabilities of engineering personnel without much special training. The bulk and weight are quite small. A limiting factor for some measurements may be the over-all accuracy which is stated to be now within 2%.

Neither Table II nor III is necessarily complete. The necessity of making new or special tests comes up continually for which instruments have to be devised or existing ones modified. Instruments peculiarly needed for determining the flight characteristics of helicopters and the powerplant performance of jet planes are in the development stage. Also a multitude of instruments is required for testing the flight instruments, a discussion of which is out of place here.

Tables II to IV Can Be Summarized

(a) A diverse and large number of phenomena must be measured in flight testing aircraft as shown in Table III. These break down into a much smaller group of types of instruments as shown in Table II. Of these types, pressure gages are perhaps the most used and these break down into a variety of ranges and installation conditions and into two designs based upon the operating ranges.

(b) Table IV shows that, generally, instrument elements for measuring all conditions are available for photopanel recording.

(c) Table V also shows that many instrument elements are not available for electric recording; of these a few will require major development work and the others relatively minor modifications.

(d) Mechanical recorders are available in limited number for use in selected tests only.

Conclusions on Choice of Instrumentation System

Choice of recording methods are presented in Table I. The basic instrument elements required are listed in Table II and the list of measurements normally made, with the possible instrumentation for each, in Table III. The adaptability of the possible instrument elements to the various methods of recording is presented in Table IV.

Of necessity a diversity of instruments and recorders must be available in order to make tests with as little labor as possible. In some cases an indicating instrument is sufficient for obtaining data; generally a full recording system must be used. Out of this apparent disorder certain conclusions be-

TABLE III *(Continued)*

	Condition Measured	*Use*	*Instrumentation*	*Recording Method*
15.	Angular Rate Indicator (Rate of roll, pitch or turn)	CS*	Rate of roll indicator, Gyro type, indicating	Photo Panel
		X	Rate gyro with electrical resistance strain gage connected to	
			(a) Remote microammeter.	Photo Panel
			(b) Recorder.	Electrical
		L	Rate gyro with mirror, light beam reflected by mirror to moving film (NACA).	Photo, on rotating drum
	*Turn indicator can also be used for rate of roll; rate-of-pitch indicator is classified as C, not CS, since dial of turn indicator oriented to measure rate of pitch does not face camera.			
16.	Attitude (Bank, Pitch)	CS	(a) Attitude gyro.	Photo Panel
		X	(b) Above with d-c. Selsyn, Autosyn pick-up, or other electrical sensing elements, to appropriate remote indicator.	Photo Panel
	Use of element (b) would save space on photo panel and may permit amplification of gyro indication.			
17.	Stick and Pedal Forces	C	(a) Auxiliary stick or pedal with combined spring element and electric resistance strain gage, connected to	
			Microammeter.	Photo Panel
			Recorder.	Electrical
		C	(b) Auxiliary stick or pedal with combined spring and d-c. Selsyn, connected to remote indicator.	Photo Panel
	Elements (a) and (b) are alternative; element (b) has perhaps less maintenance but does not as easily fit into electrical recording.			
18.	Wheel Force and Torque	C	Auxiliary wheel with two spring elements and electrical resistance strain gages, connected to	
			(a) Microammeters.	Photo Panel
			(b) Recorder.	Electrical
		X	Auxiliary wheel with two spring elements and d-c. Selsyn, connected to remote indicator.	Photo Panel
	Status of development not as far along as for stick and pedal forces.			
19.	Control Position (Aileron, Rudder, Elevator)	C	Autosyn or d-c. Selsyn connected mechanically to control, and to remote indicator.	Photo Panel
			V-d. resistor connected mechanically to control, and to	
		A	(a) Remote indicator.	Photo Panel
		C	(b) Recorder.	Electrical
		A	Spring and electrical resistance strain gage connected mechanically to control and to	
			(a) Remote microammeter.	Photo Panel
			(b) Recorder.	Electrical
	Method used depends largely upon convenience in installation and availability of instruments.			
20.	Rotational Speed (Engine, Turbo supercharger, etc.)	CS	A-c. generator connected to remote synchronous motor-magnetic tachometer unit. Indicator either sensitive or non-sensitive type.	Photo Panel
		LS	Magnetic or centrifugal indicator connecting to rotating part by a flexible shaft.	Photo Panel
		L	Centrifugal tachometer adapted to be also maximum indicating.	Photo Panel
		X	D-c. generator for recording only.	Electrical
	Accuracy of the a-c. tachometer is about 5 rpm., uncertainty in indications of the others somewhat greater.			
20A.	Synchronizer	CS	Special a-c. motor connected electrically to two a-c. tachometer generators.	Photo Panel
21.	Engine Torque	CS	Engine power transmitted hydraulically to propeller; pressure measured by	
			(a) remote pressure gage.	Photo Panel
			(b) pressure-element Autosyn to remote Autosyn indicator.	Photo Panel
		X	Pressure measured by pressure element-electric resistance strain gage	
			(a) to microammeter	Photo Panel
			(b) to recorder.	Electrical
		X	Electromagnetic transmission of angular deflection of shaft element (Reference 30).	Photo Panel

TABLE III *(Continued)*

	Condition Measured	*Use*	*Instrumentation*	*Recording Method*
22.	Fuel Flow and Consumption	CS	Vane type variable orifice balanced by a spring; position of vane indicated by Autosyn transmitter connected to Autosyn indicator.	Photo Panel
		L	Fuel drawn during test from auxiliary tank of known volume. Time interval connected is measured.	
		X	Rotary volume displacement meter; number of revolutions measured remotely by electrical means. Measures flow when combined with time measurement.	Photo Panel
		X	A number of other methods of measuring fuel flow have been proposed, but no wholly successful instruments are available. (One is described in Reference 27).	
23.	Acceleration (All are based on the deflection of loaded spring)	C	Electrical resistance strain gage to recorder.	Electrical
		C	Optical mirror reflecting a beam of light (NACA)	Photo on rotating drum
		A	Reluctance type (Martin).	Electrical
		X	Loaded spring constituting part of a vacuum tube.	Electrical
		LS	Maximum indicating type, pointer indication.	Photo Panel
		L	Two liquid-filled chambers connected by capillary tubes, ends sealed by diaphragms to which a d-c. Selsyn transmitter is connected. Selsyn indicator (Smith, British).	Photo Panel
24.	*V-G* Record		Acceleration recorded against indicated air speed by a stylus scratching on a smoked glass plate.	Individual
		X	Dynamic recording of air speed and acceleration, both against time.	Electrical
25.	*VGAT* Record	L	Multi-pen instrument recording indicated air speed, acceleration and air pressure on one chart, against time. (Impact Register Co.)	Mechanical
26.	Time and Time Intervals	CS	Stop clocks.	Photo Panel
		CS	Stop watches.	
		C	Intervalometer, electronic type to control photo recording.	
27.	Carbon Monoxide	C	(a) Carbon monoxide indicator, heat of combustion type (MSA).	Indicating
		C	(b) Colorometric type (NBS).	Indicating
	Although rarely required, the indications of instrument (a) can be recorded electrically or on a photo panel when desired.			
28.	Wind Velocity (Portable type for take-off tests)	A	Wind vane; propeller-magnetic tachometer unit calibrated to indicate wind speed.	
		C	Vane anemometer plus stop watch.	
		X	Other designs are feasible.	
29.	Water Speed (For Seaplane take-off tests)	C	Pitot tube type.	
30.	Direction	CS	Remote indicating compass Directional Gyro	Photo Panel Photo Panel
31.	Vibration	C	Dynamic recording, with elements of proper characteristics for making the measurement, is usually required.	Electrical
		L	Several hand-held instruments are available for indicating roughly the amplitude or both the amplitude and frequency of vibration.	
32.	Detonation	L	MIT—Sperry, indicating only.	

S = Used on service aircraft or can be obtained commercially without difficulty.
C = Customary practice.
A = Alternative and available.
X = Alternative experimental, at present unavailable or performance inadequate.
L = Limited application, procurement special.
D = Desirable development but not actively underway.

come evident by a study of the tables mentioned above.

Recorders: For some time to come the most flexible and convenient method of recording will be that of photographing a panel of indicating instruments. The indicating instruments and auxiliary apparatus are largely available or can be obtained with the least difficulty. The accuracy on the whole is the best obtainable for most measured variables.

The electrical recorders printing or recording a curve available today have only a limited use. The Brown recorder, which with auxiliary switches will record a large number of variables in sequence, is used widely for making engine temperature surveys and to a limited extent to measure other quantities. Electrical recorders of the oscillograph type (galvanometer element with mirror reflecting a light onto photographic paper), with or without electronic amplifiers, are of necessity used to measure fast-changing variables, such as vibrations and, in some tests, control forces and positions and accelerations.

While no compact electrical recorder generally suitable for flight test is now available or immediately in prospect, the trend of development is in this direction. Most promising appear to be rapid-sequence recording, and recording curves in miniature. The development apparently will come first for other and broader applications.

Individual recorders of the mechanical-optical and electrical-optical types are feasible for general use and in fact are used as the primary method by the NACA. Owing to the additional labor and expense of maintenance, installation and procurement, it cannot be recommended in comparison with the photo-panel recorder. However, in the hands of the NACA it has worked excellently in the research testing of airplanes.

Mechanical recorders (barographs, V-G recorders, VGAT recorders, differential pressure recorders) are of limited and specific application and add an element of flexibility and convenience to any general system adopted. Extension of their use on any other basis is impractical.

Instrument elements. Most instruments are of necessity remote indicating. If dynamic recording or telemetering is required, the output of the measuring element must be a voltage. There is the possibility of the development of electrical recorders suitable for general use in flight testing, in which case the output also should be electrical in nature. Further, the installation and maintenance of electrical leads between the recorder and measuring element are less difficult than air-tight pressure lines or mechanical connections. For a photo-panel recorder the electrical indicator is at no disadvantage compared with other types. On the other hand, to

TABLE IV—AVAILABILITY OF INSTRUMENTS FOR THE VARIOUS TYPES OF RECORDING

INSTRUMENT ELEMENTS FOR PHOTO PANEL RECORDING

(The instruments are numbered the same as in Table III.)

(a) Customary, using service type instruments
- 1. Sensitive altimeter
- 2. Airspeed indicator
- 4. Mach meter
- 8. Resistance thermometers, except free air

11 & 12. Differential pressure gages
- 13. Manifold pressure gages
- 15. Angular rate indicators roll and turn
- 16. Attitude gyro
- 20. Electric tachometers
- 20a. Synchronizer
- 21. Engine torque meter
- 22. Fuel flow-rate meter
- 26. Time pieces

(b) Customary, using instruments specially developed
- 6. Gas velocity meters
- 7. Resistance thermometer, free air
- 14. Yaw & angle of attack meters
- 17. Stick & pedal force indicators
- 18. Wheel force and torque indicators
- 19. Control position indicators

(c) Available but infrequently photographed because of insufficient accuracy or of little need.
- 3. True airspeed meter
- 10. Rate of climb indicator
- 30. Remote-indicating compass
- 30. Directional gyros

(d) Available but with other methods of recording preferable.
- 9. Thermocouple thermometer
- 27. Carbon monoxide indicator

(e) Instrument elements in general requiring dynamic recording and therefore not adapted for photo panel recording.
- 23. Accelerometer
- 31. Vibrometers

INSTRUMENT ELEMENTS FOR DYNAMIC OR ELECTRICAL RECORDING

Not available; development in progress or feasible.
- 6. Gas velocity meters

11 & 12. Differential pressure gages
- 13. Manifold pressure gage
- 14. Yaw and angle-of-attack meters
- 15. Rate of roll gyros
- 21. Engine torque meter

Not available; development of accurate transmitters feasible but difficult.
- 1. Sensitive altimeter
- 2. Airspeed indicator
- 3. True airspeed meter
- 4. Mach meter
- 16. Attitude gyros
- 20. Tachometer
- 22. Fuel flow-rate meter

Instruments of limited application, development required.
- 30. Compass
- 30. Directional gyro

INDIVIDUAL RECORDERS NOW AVAILABLE, RECORDING BY STYLUS, PEN OR PHOTOGRAPHICALLY

1. Barograph	L
2. Airspeed recorder	L
23. Accelerometers	C
24. V-G recorder	L
25. VGAT recorder	L
31. Vibrometers	C

INSTRUMENTS ORDINARILY USED INDIVIDUALLY IN AIRCRAFT OR ON THE GROUND

27. Carbon monoxide indicator	C
28. Wind velocity indicator	C
29. Water speed indicator	C
31. Vibrometers	L

L = Limited application, procurement special
C = Customary practice

secure an electrical output in many cases complicates the design of the measuring element and for some variables will require considerable development work to secure adequate accuracy. The important conclusion is thus reached, that where possible, measuring elements for maximum utility should have an electrical output, so chosen that it will serve to actuate either a remote indicator for photo recording, or an oscillograph and potentially an electrical recorder when available for flight testing, and possibly for telemetering. On these grounds development work should favor the electrical type transmitter when compatible with the accuracy and sensitivity required.

The electrical-resistance strain-gage type transmitter is ideally suited for many instruments in which a strain is essentially to be measured. Its accuracy is somewhat low for some applications, however, particularly pressure-altitude and indicated air speed.

Other methods of electrical transmission commonly available are voltage-dividing resistors (sometimes called "potentiometers") the output of which can be fed directly into a recorder, d-c. Selsyn, Autosyn and Magnesyn, all of which require adaptation for electrical recording. Reluctance and capacitance methods in general require amplifiers, and follow-up systems require relays and other additional equipment, which is a disadvantage in their employment except when there is no other feasible solution.

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A Multi-channel Oscillograph Utilizing Color Film

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Summary: This article describes a recorder consisting of four linear amplifiers integral with a six-element oscillograph galvanometer which photographically records galvanometer deflections proportional to four incoming-signal levels and to two differences between pairs of signal levels. The use of a fast color film and separate color filters permits rapid interpretation and resolution of the six complex interwinding traces.

Introduction

DEVELOPMENT of guided and self-controlled missiles required the simultaneous development of compact, self-contained recording equipment to facilitate study and rapid analysis of the performance of the missile under actual operational conditions. A recorder, to be useful in this application, must be rugged and compact and must record simultaneously a number of independent variables with high accuracy and resolution.

Commercially-available recorders are likely to meet certain of the above specifications, but suffer from one or more of the following shortcomings:

1. Simultaneous recording of more than one variable is limited by either (a) a loss of resolution due to a lack of individual trace identification; (b) a loss of accuracy caused by restricting each variable to a small portion of the recording medium; or (c) a loss of detail caused by assigning a definite trace width, modulation, or other coding to each of the variables.
2. Excessive size.
3. High-frequency response has been sacrificed for high sensitivity, or vice versa.
4. High-capacity power supply required.

The recorder described in this article and illustrated in Fig. 1 represents an effort to overcome these limitations.

This instrument utilizes 70-mm. photographic film as the recording medium; the obvious difficulty of analyzing several overlapping traces on standard black-and-white film being circumvented by the use of color film and a separate color for each of the traces. This allows the entire width of the film to be used by each trace, which in turn enhances both resolution (precision) and accuracy.

The instrument is capable of recording four signals, each of which is of the order of ten microvolts, and is able to follow time variations occurring at frequencies up to 200 cps.

In certain types of analysis it is desirable to determine a statistical correlation factor between the fluctuations in adjacent channels. To facilitate the determination of the degree of correlation, it was desirable to record the differences between incoming signals as well as the level of each signal; the recorder is, therefore, equipped to record and identify six traces.

The discussion of the system will be divided into two parts: (I) The Electronic System; (II) The Galvanometer Oscillograph.

I. The Electronic System

Electronically, the system may be divided into the following subdivisions:

1. A-c. Amplifiers.
2. Rectification and Subtraction of Adjacent Pairs of Signals.
3. Galvanometer Deflection Amplifiers.
4. Calibration Oscillator.
5. Power Supply.

1. *A-c. Amplifiers.* Each of the four channels contain a high gain voltage amplifier, the gain of which may be continuously varied from 60 db to 120 db.[1] This is achieved in a resistance-capacitance coupled pentode amplifier comprising four stages, each of which has an over-all voltage gain of 30 db and 10 db of current feedback. The use of double section, staggered resistance-capacitance interstage coupling networks limits the over-all band-width of each channel to 35 kc. centered about 30 kc.

2. *Rectification and Subtraction of Adjacent Pairs of Signals.* The a-c. output of each amplifier is impedance coupled to a symmetrical rectifier system which delivers both positive and negative voltages of equal magnitude and with identical time constants to the d-c. galvanometer deflection amplifiers. The circuit of the rectification and subtraction stage is shown in Fig. 2. This circuit functions as follows: On negative peaks of the input signal, the diode draws current causing the voltage to be equally divided between the two "peaking" networks. During the positive peaks of the input signal, the diode "blocks," applying all of the voltage to the first peaking network where an addition of the positive and negative voltages takes place. This action results in a net positive voltage of approximately $\frac{1}{4}E_{rms}$ across the second peaking network and a negative voltage of approximately $\frac{1}{4}E_{rms}$ across the first. These voltages are then applied to a pair of resistance-capacitance filter networks which are closely matched on a time-constant basis. These filters determine the maximum fluctuation frequency that may be delivered to the galvanometer.

To facilitate the determination of the degree of correlation between the fluctuations of adjacent input signals it

(1) db, as used here, ignores the input-output resistance ratio and is expressed by 20 log E_o/E_i.

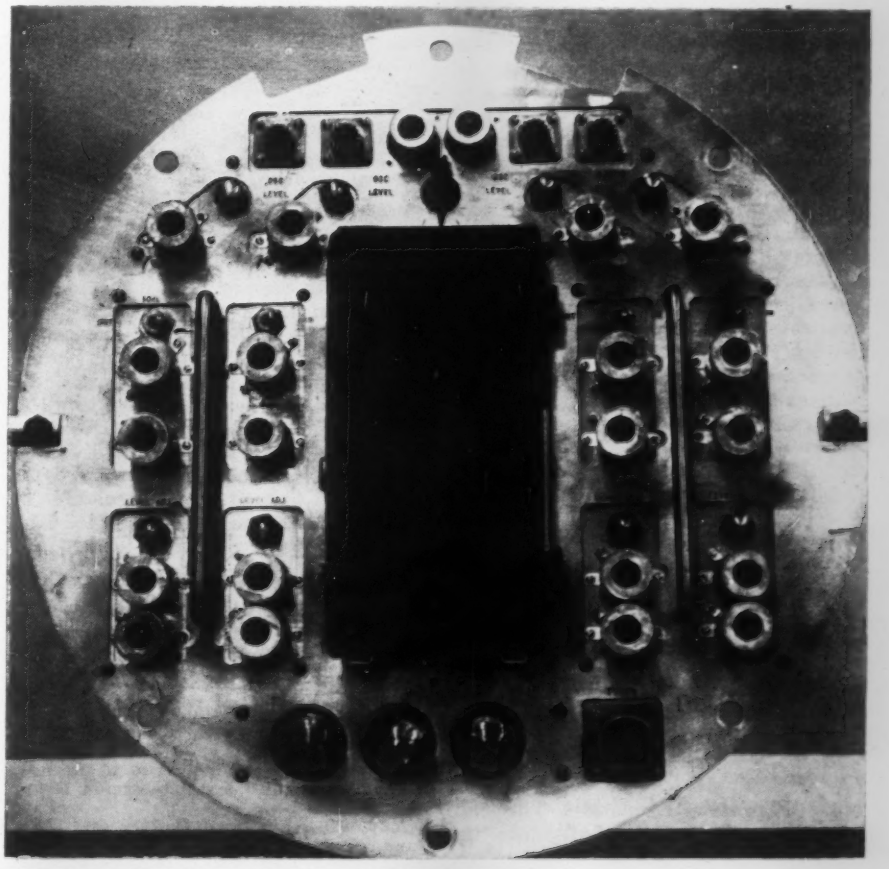

Fig. 1. Recorder Ready for Use.

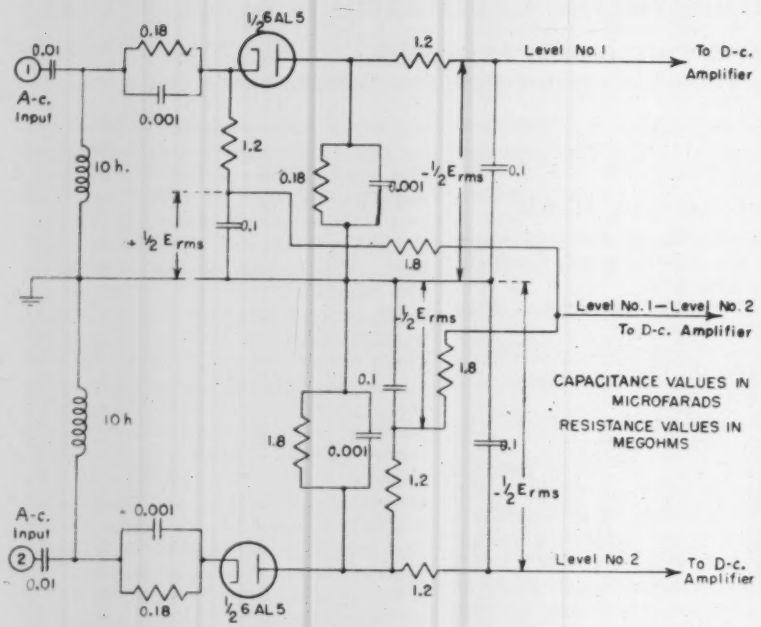

Fig. 2. Rectification and Subtraction of Signals.

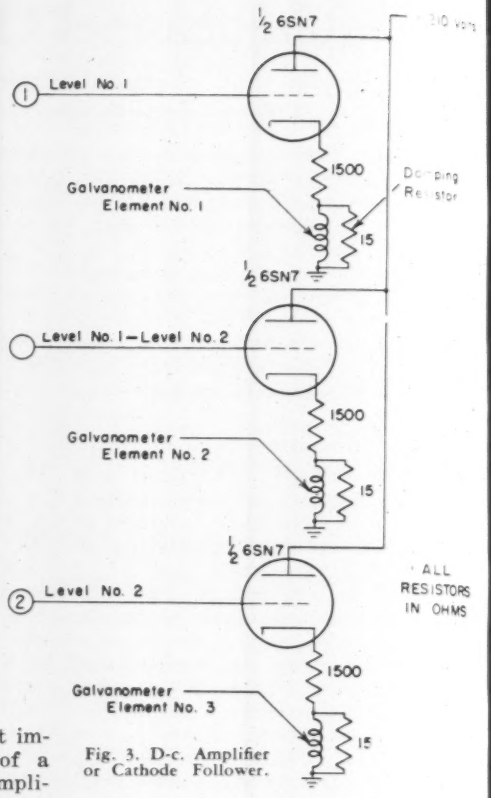

Fig. 3. D-c. Amplifier or Cathode Follower.

was desirable to record the differences between incoming signals as well as the level of each signal. To do this, the positive voltage from one rectifier is combined directly with the negative voltage from an adjacent rectifier through isolation resistors, thus producing a voltage which is proportional to the difference between pairs of input signals.

3. *Galvanometer Deflection Amplifiers.* Since the output impedance of the rectifier system is quite high, it is impractical to drive the galvanometer directly. For this reason a triode connected as a cathode follower impedance transformer (See Fig. 3) has been introduced between the rectifier and the galvanometer. A direct-coupled stage of this type is sensitive to heater supply voltage variations which result in a change in the effective grid bias on the tube. This effect is not caused by a loss in cathode emission, since the tube is always operated in its space-charge-limited state, but rather by variations in "contact" potential, etc., that are rather complex functions of heater voltage. Output current variations that are caused by this effect were minimized by driving the cathode follower negatively from the rectifier, thus combining the positive variations across the rectifier with the negative variations across the cathode follower grid. The tendency toward current variation in the galvanometer as a function of supply voltage was further minimized by regulating the plate voltage.

The galvanometer elements are placed in series with the cathodes and shunted with sufficient resistance to give an optimally flat response to the galvanometer.

4. *Calibration Oscillator.* The calibration oscillator was built into the recorder in order to insure that microphonic effects, variations in supply voltages, or other effects were not imparing the records. By means of a timing circuit the input to the amplifiers is automatically switched between the calibration oscillator and the signal several times during the run, thus enabling a running check to be made on the validity of the record.

The oscillator is a modified Hartley oscillator designed to give a stable output voltage in the presence of supply voltage variations. A cathode-follower buffer stage prevents possible variations in the load from affecting the output voltage, and also serves to reduce any tendency towards cross-talk by reducing the output impedance of the system. An attenuator following the buffer provides a variable a-c. output ranging from −100 db to −40 db.[2]

5. *Power Supply.* The power supply consists of three small Willard[3] storage batteries that will allow the system to operate for one hour with no change in performance. These batteries are used to supply heater voltage to all of the tubes as well as to drive an Eicor[4] dynamotor which supplies plate voltage to the system. The output of the dynamotor is filtered and regulated by means of a resistance-capacitance filter and two voltage regulator tubes.

II. The Galvanometer Oscillograph

The primary design consideration in the development of the galvanometer oscillograph was a minimum of size consistent with intelligibility of the record and over-all reliability. Spatial and resolution requirements suggested the use of color film so that each trace could employ the entire width of the film and still be readily distinguishable from neighboring traces. On these bases a fast 70-mm. color film was indicated. Eastman Koda-Color Aero Film[5] was chosen because it had the fastest emulsion (Weston rating of 32) of the several films considered.

The heart of the oscillograph is a six-element string galvanometer containing cylindrical mirrors having radii of curvature of 11½" and an open-circuit sensitivity of 8.2 degrees per milliampere.[6] In this application the galvanometer elements are optimally damped with 14-ohm resistors, resulting in a frequency response that is flat to within one db from 0 to 200 cps. and falls off at the rate of six db per octave above this point. The net sensitivity of the elements is then four degrees per milliampere.

Light is supplied to the galvanometer in the form of six separately-colored collimated light beams, one for each element. This procedure permits placing the exposure plane at the focal point of the cylindrical mirrors (5¾") and allows further space conservation since the film spools may be placed in the space between the collimator and the exposure plane as shown in Figs. 4 and 5. The use of the prism system allows the light source to be placed out of the path of the galvanometer beam and permits placing the bulb in a readily-accessible location without increas-

(2) db here is equivalent to 20 times the logarithm of the magnitude of the voltage in question.

(3) Willard Storage Battery Co., Cleveland, Ohio.

(4) Eicor, Inc., Chicago, Illinois. This unit is rated at 350 volts, 160 ma.

(5) This film was obtained by special arrangement with the Eastman Kodak Co.

(6) Manufactured by the Technical Instrument Co., Houston, Texas.

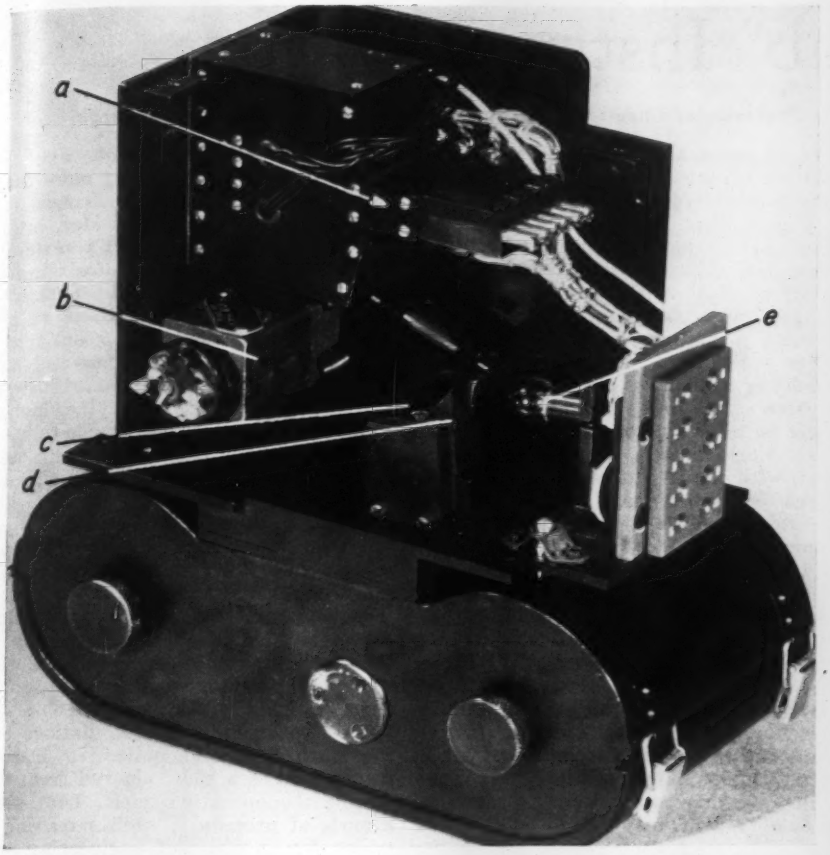

Fig. 4. The Galvanometer Oscillograph Unit. (a) Galvanometer; (b) Film drive motor; (c) Color filters; (d) Collimating unit; (e) Line filament lamp.

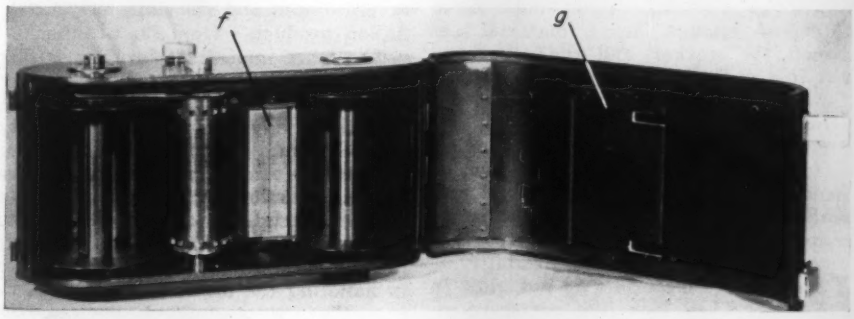

Fig. 5. The Film Magazine. (f) Exposure slit; (g) Pressure plate.

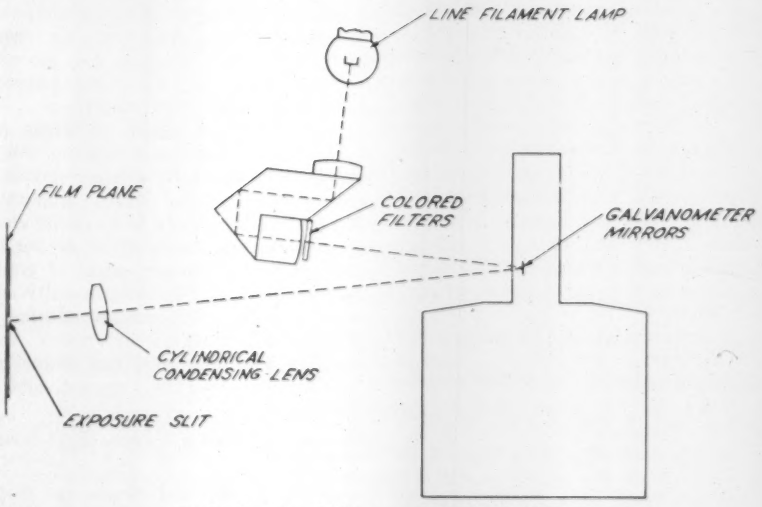

Fig. 6. Functional Diagram of the Optical Train

ing the size of the case. It will be noted that the color filters (*c*, Fig. 4) are placed directly after the lens-prism unit (*d*, Fig. 4) so that the light beam for each element passes through the filters only once before being reflected by the galvanometer mirrors. The use of a line filament lamp eliminates the necessity for a condenser and slit system to produce the desired line source. A brighter image is achieved by inserting a cylindrical condensing lens just before the exposure plane. The light then passes through a slit (*f*, Fig. 5) 0.006" wide, which limits the length of the spot impinging on the film. Fig. 6 illustrates the functional aspects of this optical system.

For ease in analysis, it is desirable to have a uniform time base for the record. During the war several fractional-horsepower motors containing integral governors were developed. These motors exhibit a remarkably flat speed-load and speed-voltage characteristic and are physically small. The use of such a motor produces the desired linear time base without additional components. The motor chosen to drive the film[7] was designed for operation at a nominal terminal voltage of six volts; however, since the film presented a rather heavy load to the motor and since the battery voltage tends to drop during the run, the motor was rewound so that rated speed would be obtained at 4.5 volts. With this modification, the motor is able to drive the film at a constant speed of 0.75" per second with good speed regulation during the entire run. In order to reduce objectionable sparking of the contacts of the centrifugal governor, a pair of 100-ohm resistors was strapped across the contacts. This value satisfactorily reduces the interference fed back through the power line, while having a negligible effect on the speed control of the motor.

The film magazine containing 50 feet of film (sufficient for a 13-minute run) is attached to the oscillograph by means of a pair of snap clips and centering pins which permit ready removal of the magazine to the darkroom. Driving is achieved by means of a pair of spur gears which mate as the magazine is installed. Although there is no shutter, only a small section of the film is exposed when the magazine is removed for developing, since the pressure plate (*g*, Fig. 5) holding the film firmly against the exposure plate serves as sufficient baffle to prevent general fogging of the film.

Future Development. Further development using sub-miniature components and unitized construction is being carried out in the interest of still further space conservation, a wider range of application and improved serviceability. The development of a stable, compact logarithmic amplifier which will result in an increased dynamic range is also being considered.

(7) Delco Appliance Division, General Motors, No. 69610.

"Hot Lab" Instrumentation*

By CLAUDE R. SCHWOB, Assistant Professor of Chemistry, Carnegie Institute of Technology, Pittsburgh.

STUDY of radioactive atoms in the laboratory can lead to the solution of many theoretical and practical problems. The physicist studying their "birth" in an accelerator or pile learns much about the nature of matter. The chemist, physicist, engineer, metallurgist, biologist and physiologist adapt the "death rattle" of these atoms to problems the solution of which would be impossible without the aid of tracer techniques. The nuclear scientists and power engineers in maintaining the coming chain-reacting piles capable of delivering enormous amounts of useful power deal with many isotopes as secondary products which must be removed from the reacting system for maximum efficiency.†

As noted by Levy[1] there are three levels of radioactivity: the micro- and millicurie level of the tracer scientist, the curie level of the cyclotron physicist and the multicurie levels of the pile technician.

The qualities which make radioatoms ("hot" atoms) useful to science and industry make them hazardous to handle. Hence the need of a new type of laboratory ("hot lab") in which hazards to personnel are minimized. The hot lab, as usually designed today, is unsatisfactory.

Protection of the health of the workers is the most important requirement of all. The experience of the relatively old radium industry and the thorough experimental study started by the Manhattan District and continued by the Atomic Energy Commission and its contractors in various universities have led to definite conclusions regarding (1) the safe limit of exposure to external radiation and (2) the amounts of various radioactive materials which can be safely tolerated in air, on the skin, or within the body. In general, the maximum dose of external radiation considered safe over an indefinite period of time is 0.01 *R* per day (1 *R* ≡ 1 Roentgen; that is, radiation which, under standardized conditions, will cause 1,000 ionizations /cm.[3]).

The problem of designing a hot lab resolves itself into this one factor: *without unduly affecting the ease and efficiency of manipulations, each hot lab worker must receive less than 0.01 R of radiation per day.*

Radiation exposure may be controlled in many ways. Obvious ones: (1) control of amount of radiating material; (2) use of shields; (3) control of time of exposure; (4) use of distance.

Under ideal conditions all four of these safety measures would be used. However, it usually is impossible to apply all at once. For example, it often is absolutely necessary to work with intense activities. In such cases the other precautions must be emphasized: shielding must be thicker and more extensive, time of individual exposure must be reduced (by relays of workers, each working only a specified time), and, with the use of remote-control devices, operators must be located at a greater distance from the radiation source.

Let us first consider the physical disposition of the hot lab from the viewpoint of personnel protection.

Different radioisotopes emit varying intensities of different radiations. Coming from an external source—that is, outside the skin — alpha radiation is practically harmless owing to its low penetrating power. Two inches of air, a sheet of good paper, a thin rubber glove will stop this radiation. The same, to a lesser extent, may be said of the beta radiation: a few inches of air or the glass wall of a beaker will prevent damage. Gamma radiation, however, cannot be completely eliminated by shielding. All that can be done is to interpose enough dense material between the worker and the source to cut this radiation down to a safe limit for a reasonable working time at the required distance.

Radioisotopes in contact with living tissue, either on the skin or mucosa, or inside the body, are dangerous. Especially insidious is the absorption of material through the lungs. Microgram amounts may cause lasting disability.

Radioactive materials do not glow in the dark. They look like perfectly innocent counterparts of their stable brothers. But it is one of the paradoxes of nature that living tissue acts as an efficient detector for their radiation—good only once, however—while the scientists are wracking their brains devising more practical and *more rapid* means of detecting these oft-elusive rays. More rapid, because it is an insidious part of these rays' harm that the physiological symptoms of damage are delayed for days, months, or years.

Therefore, we see that, in addition to shielding and distance, suitable protective devices are required to prevent contact of any radioisotope with the body, or its inhalation. Shielding, protective clothing, ventilation, respirators: all these are required. But to what extent? Again, we must consider the varying needs of different workers.

Taking the extreme case, that of the pile technician or the physicist working with the products of a high-power accelerator, the need for shielding and ventilation is all-important. For the handling of samples having more than 5 or 10 curies of activity (considered to be gamma activity of 1 Mev. intensity, a good average value) the shielding must be of the order of six inches of lead in order to allow the worker to remain in the vicinity (three to six feet) of the operations for about thirty minutes a day. Concrete two-and-one-half times as thick can be used instead of the scarce lead. With the higher orders of activity it is desirable to have the working space completely enclosed by the shield. Optical instruments, such as modified periscopes (providing no straight path for the radiation) or television devices permit some visual observation of what is going on within the shield. When dealing with often-repeated operations, such as those which conceivably would be connected with the maintenance of a power pile, the shielded area may well contain equipment designed so that no visual observation is required, all manipulations being controlled, and indicating instruments read in a spot removed from the site of the operation itself. That such a mode of procedure, while requiring a tremendous amount of engineering and development, is practical is shown by the successful operation of the present chain-reacting piles and the separation of plutonium and the extremely active fission products[2] from the uranium.

The more immediate problem is that of the laboratories handling smaller amounts of radioactivity. Samples of 1 to 5 curie may be needed for a variety of operations: physical tests, chemical purification or separation of the various activities, influence of radiation on other materials or operations. In such cases, an open-top shielded area may prove most practical. For convenience in handling the material and in mounting the remote-control devices, the shield should not be thicker than one foot. Such an amount of concrete affords good protection. If an occasional sample is especially active, and the required operation long, workers can be rotated so that each one does not exceed his safe daily "dose" of radiation.

One of the biggest problems in all laboratories handling radioactive substances is that of contamination. All surfaces must be hard, smooth and streamlined in order to be easily cleaned, since less than 10^{-12} gram of hot material may be a severe cause of contamination, and, if unintentionally mixed with another radioactive species, may nullify the results of many experiments.[3] Stainless steel has proved satisfactory for working areas, and hard

*Presented in part before the joint Physical Society of Pittsburgh-I.S.A. Session on "Instrumentation in Atomic Energy Research" at the first Instrument Conference, Pittsburgh, September 19, 1946.

†Excluded from this discussion is any consideration of the problems facing the operator of a chain-reacting pile or of an accelerator. This article deals only with problems arising after the radioisotope is produced.

(1) Henri A. Levy, "Some Aspects of the Design of Radiochemical Laboratories," *Chemical and Engineering News*, Vol. 24, 1946, pages 3168-3173.

(2) Plutonium Project Report. "Nuclei Formed in Fission," *Journal of American Chemical Society*, Vol. 68, 1946, pages 2411-2442.

(3) C. R. Schwob, "Purity of Radioisotopes Used as Tracers," to be published, 1947.

tile is probably suitable for walls and floors, although the use of some of the newer industrial plastic tapes (obtainable in widths up to eighteen inches or more) as wall and surface covering has many advantages. These may be replaced readily when contaminated.

The most innocent objects are to be watched for contamination: doorknobs, telephones, service outlets, etc. They should be handled with cleansing tissue. It is surprising how rapidly a stray bit of radioactivity on a stool, for example, spreads among personnel!

For the average worker's protection, the open-top shield should be about 6½ ft. high, if the working surface is 3 ft. or less from the floor. A system of mirrors over the area permits some visual observation, and periscopes and remote-control devices running on tracks on the top of the shield permit a wide latitude in operations. Some workers prefer the shielded area in the center of the laboratory so that the operations may be observed and controlled from all sides. Strong ventilation must be provided over the shield, and workers should wear efficient respirators.

Only small amounts of radioactive materials are used generally in tracer work. In any individual experiment less than 100 microcurie of activity is needed.[1] An improvised shield made by stacking lead bricks will furnish sufficient protection against gamma rays, while no shielding is required for beta rays.* Storage of the supply of isotopes needed for a series of experiments presents no peculiar problem. In the amounts usually obtained[4] an inch of lead will reduce radiation to a safe amount especially if the storage area is in an isolated part of the building.

Special Instruments

It is not within the scope of this article to discuss the instruments needed in the counting room. However, a means of estimating the radioactivity of samples ("counting") is required in the hot lab. This may be in the form of a Lauritzen electroscope, a G.M. counter with scaler, or an ionization chamber, according to the type of radiation and the choice of the worker.

In the hot lab itself, it is necessary to keep a continuous check on the activity. The counter mentioned above may be adapted for this purpose, or an *R*-meter (giving instantaneous readings in *R*'s per eight-hour day) may be used. The radiation dose of individual workers is measured by means of pocket electroscopes or pocket ionization chambers or by means of film badges which may be obtained sensitive to beta, gamma and neutron radiation.**

For monitoring (that is, checking working areas and workers for contamination) it may be found economical to mount a G.M. tube in a special housing and connect it to the hot lab scaler by means of a cable.[5]

Besides the equipment for measuring the radioactivity, all the ordinary paraphernalia of a laboratory is needed in the hot lab. Insofar as possible, all equipment must be smooth, streamlined, and easily cleaned if it is not expendable. This may call for special stainless steel covers for frequently-used electrical or precision instruments. For occasional use, a good grade of wrapping paper, to be disposed of after the experiment, is quite satisfactory. Where the apparatus is to be observed visually, cellophane is a handy protection.

The handling of low-level activities[1] (milli- and microcuries) requires no special equipment. The lead shield, if used, may be arranged to interfere little with manipulations. Ordinary forceps and tongs are suitable for handling hot samples and glass containers.

In the real hot lab, that is the laboratory handling curies of activity, we run into many manipulative problems none of which is readily solved. All operations must be conducted at a distance through or over an awkward shield.

The active material is usually brought into the hot lab in a heavy lead container. It must be opened only behind the shield, the sample removed, partitioned and prepared for the operation required. A laboratory should standardize, if at all possible, on one design of lead container with an opening and emptying device easily worked at a distance. With the sample still in the container, a worker can go behind the shield, position the container and attach the controls to the opening devices. Once the container is open, no one should venture behind the shield. In case of a calamity, such as a spill, which prevents the return of the hot material to its shielded container, a flushing or other device can be used to gather the bulk of the hot material into a shielded sump below the shielded area, where it can be recovered.

The hot sample is at all times handled by remote control. Three kinds of devices have been proposed: mechanical, magnetic, and hydraulic. Devices of each of the three kinds are fairly efficient but much development work remains to be done in the field. The present devices, moreover, require a long learning period for the operator, and enough dry runs for the operator to know clearly what cannot be done.* It is while trying to use them that a man wishes he had three or more hands. It is difficult to translate a motion such as grasping a beaker into the turning of a knob. The action of pouring becomes a twist of a lever. When several of these actions must be combined, and the eyes observe them transposed and from an unfamiliar angle in mirrors, nervous strain is inevitable. The operator needs all his self-control to restrain himself from jumping over the shield and performing the operation with his fingers. The radiation is not felt, nor visible; the fingers likely will cease to be either if the impulse is obeyed.

At present, in the author's experience, most remote-control devices are designed to handle ordinary laboratory equipment. It seems probable that these devices could be made simpler, more efficient, less bulky and more easily decontaminated were the equipment they are designed to handle adapted to the remote control, rather than the other way around. For example, a beaker grasped by the finger-like tongs of a device is held precariously. Were the container made with a flat top, not only would danger of a spill be diminished, but a simple suction device would afford a firm and positive grasp of the object. Other containers could be built with inserts of magnetic material and grasped with electromagnets: this particular scheme seems especially valuable in facilitating the transfer of an object from one manipulator to another.

For liquids, it would seem worthwhile to design and build a continuous glass device, wherein a wide variety of operations could be conducted once the liquid is introduced into the apparatus. For example, reagents, previously located in the apparatus, could be added, then pressure or suction would transfer the products to another part of the apparatus where filtration would take place, then to another portion where electrical measurement or distillation or crystallization could be performed. Such a scheme would be invaluable in, say, the separation of one activity from another by chemical means, or the large-scale synthesis of compounds containing tagged atoms.

Removing samples from behind the shield should offer no difficulty. In physical operations, the sample is often kept whole, and can be returned by a manipulator to its original shielded container. In chemical operations, in many cases the various activities of the sample are separated, and each fraction is less active than the whole, and can be placed in its own container.

Waste materials, if radioactive, must be buried. Liquids may be run into a deep septic tank and, if necessary, the area above it may be fenced off.

One of the important bottlenecks in the expanding use of radioactive techniques is the lack of suitable equipment for the hot lab. It is to be hoped that the pressure of the necessity for remote controls will result in the development of adequate devices in the near future.

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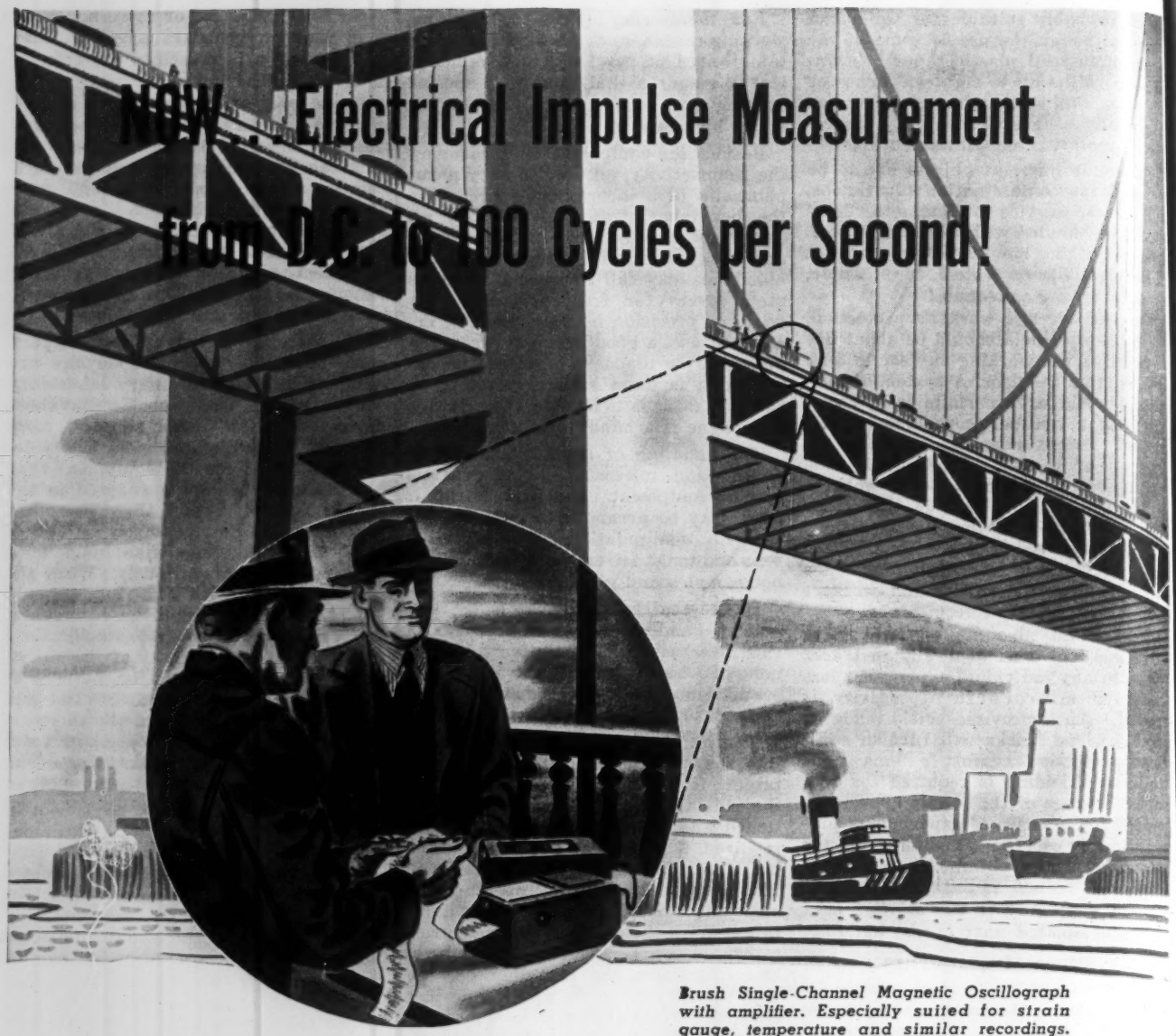
*Not only is gamma radiation much more penetrating than beta, but larger amounts of gamma emitters are needed in tracer experiments, owing to the low efficiency of gamma counting.

(4) Isotopes Branch, U. S. Atomic Energy Commission, "Radioisotopes, Catalog and Price List No. 2," Oak Ridge, Tennessee, 1947.

**Film badges may be obtained from the Isotopes Branch, Atomic Energy Commission, Oak Ridge, Tennessee.

(5) C. R. Schwob and R. Nether, "A Monitoring Probe for Radiochemistry Laboratories," *Science*, 1947 (in press).

*In this respect, it may be pointed out that rehearsals and dry runs are in themselves wonderful measures. After these, not only is the operation more efficiently performed and the risk of failure minimized, but it is faster, and the exposure of the operator may be cut down considerably.



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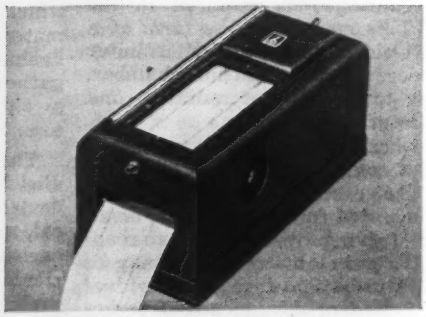

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Program *of the* Second Instrument Conference *and* Exhibit

CHICAGO, ILL., SEPTEMBER 8, 9, 10, 11, 12, 1947

I.S.A. Technical Program

Tuesday, Sept. 9 — 9:00 a.m., Grand Ball Room

I.S.A. Session No. 1 on Quality Control. Chairman, E. H. Robinson (Johnson & Johnson, Chicago, Ill.)

"Quality Control—A Management Tool for Process Industries," by W. E. Jones (Management Controls, Desplaines, Ill.) Paper No. 47-1-1.

Abstract. Illustrated talk on the history and development of modern statistical quality control; on the use of this technique by industrial management; on the basic statistical methods involved; and on the various applications (accomplishments) made in different industries.

"A Technique for Estimating Precision of Measurement," by F. Trowbridge (Sentinel Radio Company, Evanston, Ill.) Paper No. 47-1-2.

Abstract. Presents a statistical test for determining the total error of measurements for many inspection instruments. This test makes efficient use of the collected data in a practical manner to make the test economical and easy enough to be applied by an ordinary inspector. "How good is your data?" Here is an answer basic to any well-designed quality control program.

Tuesday, Sept. 9—9:00 a.m., North Ball Room

I.S.A. Session No. 2 on Industrial Use and Measurement of Radioactive Materials. Technical Chairman N. Hilberry (Argonne National Laboratory, Chicago, Ill.)

"The Fundamentals of Radioactivity," by G. J. Overbeck (Northwestern University, Evanston, Ill.) Paper No. 47-2-1.

Abstract. Reviews history since Becquerel and the Curies; describes atomic structure in terms of component particles and energies; outlines the uranium series and explains "parent atoms," "half-lives," etc.; discusses collisions, transmutations, etc., both natural and artificial, with emphasis on energy balance, stability or instability, etc.

"The Application of Radioactive Indicators to Industrial Problems," by R. D. Evans (Massachusetts Institute of Technology, Cambridge, Mass.) Paper No. 47-2-2.

Abstract. Topics discussed: industrial quality-control problems; fundamental and applied research on the mechanism of certain industrial processes; identification of manufactured articles; industrial hygiene problems.

"Instruments for the Measurement of Tracer Radiation," by F. R. Shonka (Argonne National Laboratory, Chicago, Ill.) Paper 47-2-3.

Tuesday, Sept. 9—2:00 p.m., Grand Ball Room

I.S.A. Session No. 3 on Chemical Concentration. Technical Chairman H. C. Frost (Corn Products Refining Company, Argo, Ill.)

"Applications of Viscosity Measurements in Petroleum Refining Operations," by D. J. Pompeo (Shell Development Company, Emeryville, Calif.) Paper No. 47-3-1.

Abstract. Discusses application of viscosity measurements to the control of petroleum refining operation as applied to lubricating oils, fuel oils, diesel fuels, jet fuels and various types of cut back asphalt. Indicates places where automatic recording and control instruments for continuous measurement of viscosity would aid in the control of refinery processes.

"Polarographic Analysis—Principles, Techniques, and Applications," by L. D. Wilson (Corn Products Refining Company, Argo, Ill.) Paper No. 47-3-2.

Abstract. Briefly covers early history of subject. Develops basic theory leading to the Ilkovic equation and its meaning and application, together with the essentials of instrumentation. Discusses the several models of Sargent polarographs and the L&N Electrochemograph in the recording class, and the Fisher Electropode in the manual class. Explains qualitative and quantitative significance of typical polarographic curves. Discusses reasons for resorting to polarographic techniques and describes examples of technique and practice in industrial applications, especially in the analysis for trace constituents in alloys and major constituents in plating solutions.

"Adaptation of the Automatic Spectrophotometer for Special Measurements," by R. H. Kienle and E. I. Stearns (Calco Chemical Division, American Cyanamid Company, Bound Brook, N. J.) Paper No. 47-3-3.

Abstract. The G-E automatic recording spectrophotometer may be used for other measurements than color: chemical identity, quantitative chemical analysis, reaction rates, refractive index, extinction coefficients, rotary dispersion, and dichroism. Measurement of these properties is facilitated if certain modifications are made to the instrument and to the sample holders normally provided with it.

"Some Problems of Application of Conductivity Equipment," by A. L. Chaplin (Askania Regulator Company, Chicago, Ill.) Paper No. 47-3-4.

Abstract. Problems encountered in application of conductivity methods in the measurement and regulation of chemical processes. Advantages which this method has over other physical measurements for certain applications; and limitations of the method. Importance of concept of direct measurement of molecular species. Examples of application-proven methods of use.

Tuesday, Sept. 9—8:00 p.m., Grand Ball Room

I.S.A. Session No. 4, Automatic Control and Servomechanism Symposium. Technical Chairman R. W. Jones (Northwestern University, Chicago, Ill.)

"Practical Application of Automatic Control Theory (including demonstration)," by Donald Campbell (M.I.T., Cambridge, Mass.)

Wednesday, Sept. 10—9:00 a.m., Grand Ball Room

I.S.A. Session No. 5 on Automatic Control. Technical Chairman R. Webb (Carbide and Carbon Chemical Company, Charleston, W. Va.)

"Demonstration of Automatic Control Principles," by Gerald F. Akins, assisted by John H. Kowalski (Eastman Kodak Company, Rochester, N. Y.)

Wednesday, Sept. 10—2:00 p.m., Grand Ball Room

I.S.A. Session No. 6 on Plant Practices. Technical Chairman W. S. Hitt (Socony-Vacuum Oil Co., Hammond, Ind.)

"Instrument Installation and Maintenance Methods and Practices in a Modern Oil Refinery," by G. A. Larsen (Texas Company, Lockport, Ill.) Paper No. 47-6-1.

Abstract. Discusses some of the principal factors concerning the installation and maintenance of instruments in the modern oil refinery. Adequate shop facilities and trained personnel are prime requisites of an efficient instrument department. Standardization of instrument installations simplifies the training problem and results in increased departmental efficiency and appreciable savings in time and material. Describes shop practices and short cuts that have contributed much toward efficiency.

"Instrumentation in Turbine Testing," by A. B. Sisson (Public Service Company of Northern Illinois, Chicago, Ill.) Paper No. 47-6-2.

Abstract. In the testing of large central-station turbines, measurements of pressure, temperature and flow must be accurate, for the annual energy consumption of one such turbine exceeds one million dollars' worth of fuel. Flow measurement involves calibration of the flowmeter and the Venturi tube and, to a lesser extent, temperature measurement. Calibrations of thermocouples and potentiometer are also discussed. Accuracy of results obtained is viewed in the light of reproductibility; of enthalpy, and enthalpy changes, in and through various portions of the turbine; and by comparison of measured flow quantities with calculated quantities where possible. Other topics: preparations for a turbine test, personnel required and number of readings; also methods of measuring, and controlling, clearances in the turbine and the significance of this measurement.

"Instrument Servicing and Maintenance in an Educational and Research Electrical Laboratory," by H. N. Hayward (University of Illinois, Urbana, Ill.) Paper No. 47-6-3.

Abstract. Outlines practices followed in checking new instruments when received and preparing them for use. Reviews identification marking and modifications or additions found desirable in adapting commercial instruments and other laboratory items to meet storage, handling and usage conditions in a particular laboratory. Describes a combination instrument and apparatus requisition and service record system, also an instrument damage, repair and calibration data file. Gives procedures for testing and inspection that have been effective in detecting damage and other conditions requiring attention. Includes an account of organization and operation of a calibration and standards laboratory to service and maintain several hundred instruments and provide other essential services.

Thursday, Sept. 11—9:00 a.m., Grand Ball Room

I.S.A. Session No. 7 on Process Control. Technical Chairman J. G. Kerley (Shell Oil Company, New York, N. Y.)

"Instrumentation of an Acetic Acid Concentration Process," by J. E. Voytilla (E. I. du Pont de Nemours & Co., Wilmington, Del.) Paper No. 47-7-1

Abstract. Discusses a process for concentration of acetic acid in a cellulose acetate rayon process by continuous liquid-liquid extraction and subsequent rectification is discussed briefly. Emphasizes the process factors which led to a system of automatic control, the control facilities selected and the results obtained. Dscribes operating control difficulties encountered during start-up of the process, and their corrections.

"Sea Water Bromine Process Chemical Control System," by P. Hart (Dow Chemical Company, Texas City, Texas.) Paper No. 47-7-2.

Abstract. Briefly reviews history of process and then describes it in detail, with emphasis on conditions to be closely controlled. All control instruments are self-balancing potentiometer recorders of galvanometer type commanding diaphragm-motor valves through valve-positioners.

Thursday, Sept. 11—2:00 p.m., Grand Ball Room
I.S.A. Session No. 8 on New Instruments. Technical Chairman V. F. Hanson (E. I. du Pont de Nemours & Co., Wilmington, Del.)

"Moisture Measurement with an Electronic Dew Point Indicator," by V. Suomi (University of Chicago, Chicago, Ill.) Paper No. 47-8-1.

Abstract. Develops an elementary treatment of moisture relationship in the atmosphere. Shows the dewpoint method of moisture measurement to have a definite advantage over other common methods in that its percentage accuracy is nearly constant over a wide range of temperatures. Describes an electronic dewpoint hygrometer which maintains a small metal mirror at the dewpoint temperature by means of photoelectric observation and r-f. induction heating; describes its accuracy, performance, and possible industrial application.

"Instrumentation for Aeronautical Research," by Edward Blom (Cornell Research Foundation, Inc., Buffalo, N. Y.) Paper No. 47-8-2.

Abstract. Successful design of aircraft today depends much upon the skill of instrument men. Author describes a laboratory organized primarily to conduct aeronautical research, and some of the elaborate instruments used as tools of research. Discusses one typical problem.

"Design and Applications of a New Metals Comparator," by D. E. Bovey (General Electric Company, Schenectady, N. Y.) Paper No. 47-8-3.

Abstract. For non-destructive testing and identification of metal stocks and parts, an improved Metals Comparator has been developed for industrial use. Such a device was successfully used in various G-E departments during the war, and the improved design is a result of this experience. Its operation is based on comparisons of electrical and magnetic properties of both non-magnetic and magnetic metals. The simplicity and small size of the comparator make it especially suitable for production use in factories and stock rooms. Practical applications.

Friday, Sept. 12—9:00 a. m., Grand Ball Room
I.S.A. Session No. 9 on Process Control. Technical Chairman A. V. Novak (Monsanto Chemical Company, Oak Ridge, Tenn.)

"Basic Design and Field Performance of the Control and Measurement Instrumentation of an Alkylation Unit," by H. F. Moore and G. W. Gross (Standard Oil Company of New Jersey, Linden, N. J.) Paper No. 47-9-1.

Abstract. Discusses the instrumentation of a large oil refinery processing unit for production of one component of 100 O.N. gasoline (alkylate). Outlines the chemical and mechanical engineering behind the selection of control methods and equipment types is outlined. Analyzes plant performance from field records and instrument charts together with the modifications to original design that were found necessary.

"Application of Conventional Industrial Instruments to Power Plant Control," by W. H. Fortney (Humble Oil Company, Baytown, Texas.) Paper No. 47-9-2.

Abstract. Describes two installations of high-pressure boilers and their water-conditioning supply plants. Continuous automatically proportioned chemical feeding is obtained through use of orifice meters. Considerable flexibility of the steam generating plant has been obtained by adapting the valves and controllers for remote positioning or control by conventional instruments. Novel applications include firing boilers on rate-of-flow control.

Program — Industrial Instruments and Regulators Division American Society of Mechanical Engineers

Monday, Sept. 8—9:00 a.m., Grand Ball Room

"Application of Mechanical Cascade Control Systems," by J. M. Swarr, (Corn Products Refining Company)

"Floating Scale Manometers," by W. D. Wood (Taylor Instrument Companies)

Monday, Sept.8—2:00 p.m., Grand Ball Room

"Design of Instrument Gears," by G. W. Kuntney (Brown Instrument Company)

"A New System of Humidity Measurement," by W. F. Hickes (Foxboro Company)

"Various Mechanical and Electrical Digital Calculators and Their Uses," by Wallace J. Eckert (Watson Scientific Computing Laboratories, Columbia University)

Monday, Sept. 8—Gold Room, Congress Hotel, Banquet, 6:30 p.m.

Presiding—J. C. Peters (Leeds & Northrup Co.)
Welcome—Eugene W. O'Brien, President A.S.M.E.

"Personal and Professional Problems of Engineers—Aids and Barriers to Advancement," by W. Julian King (Director Sibley School of Mechanical Engineering, Cornell University)

	MONDAY SEPTEMBER 8	TUESDAY SEPTEMBER 9	WEDNESDAY SEPTEMBER 10	THURSDAY SEPTEMBER 11	FRIDAY SEPTEMBER 12
Technical Sessions 9 A.M.	ASME Industrial Instruments & Regulators Division Session Grand Ball Room	ISA Quality Control Session Grand Ball Room ISA Radiation Session Normandie Lounge ISA Electrical Instruments Course North Ball Room	ISA Control Demonstration Grand Ball Room ISA Electrical Instruments Course North Ball Room	ISA Process Control Session Grand Ball Room ISA Industrial Instruments Course North Ball Room	ISA Process Control Session Grand Ball Room ISA Industrial Instruments Course North Ball Room
Luncheon 12 Noon	S.A.M.A. South Ball Room	ASME Congress Hotel	Foreign Visitors Boulevard Room	Local ISA Secretaries Private Dining Room 4	
Technical Sessions 2 P.M.	ASME Industrial Instruments & Regulators Division Session Grand Ball Room	ISA Chemical Concentration Session Grand Ball Room ISA Electrical Instruments Course North Ball Room	ISA Plant Practices Session Grand Ball Room ISA Electrical Instruments Course North Ball Room	ISA New Instruments Session Grand Ball Room ISA Industrial Instruments Course North Ball Room	ISA Industrial Instruments Course North Ball Room
4 P.M.	ISA Annual Meeting North Ball Room				
Banquet 6:30 P.M.	ASME Congress Hotel		ISA Grand Ball Room		
Technical Session 8 P.M.		ISA Servomechanism Symposium Grand Ball Room			

NOTE: All functions and meetings are scheduled for the Stevens Hotel unless otherwise indicated.

Schedule of Educational Lectures

ELECTRICAL MEASUREMENTS—North Ball Room

TUESDAY, SEPT. 9

9:00 a.m.—**Fundamental Electrical Indicating Instrument Mechanisms,** Speaker to be announced.

2:00 p.m.—**Instrument Accessories and Auxiliary Devices,** by L. F. Parachini (Weston Electrical Instrument Corp.).

WEDNESDAY, SEPT. 10

9:00 a.m.—**Recorders and Integrating Devices,** by H. S. Day (General Electric Co.).

2:00 p.m.—**Electronic Test Equipment,** W. R. Triplett (Triplett Electrical Instrument Co.)

INDUSTRIAL INSTRUMENTS—North Ball Room

THURSDAY, SEPT. 11

9:00 a.m.—**Pressure and Thermal Systems,** by George E. Heller (Taylor Instrument Cos.).

2:00 p.m.—**A B C of Automatic Control,** by C. E. Mason (Bristol Co.).

FRIDAY, SEPT. 12

9:00 a.m.—**Flow and Liquid Level,** by L. K. Spink (Foxboro Co.).

2:00 p.m.—**Electrical Temperature Measurements,** by Martin L. Ladden (Brown Instrument Co.).

I.S.A. Plant Trips

1. Standard Oil Company's new Catalytic Cracking Unit at Whiting, Indiana on September 12th.
2. Blast Furnace, Open Hearth, and Rolling Mill Departments of the Carnegie-Illinois South Works for Friday afternoon of September 12th.
3. Central Scientific Company on Thursday afternoon, September 11th.

Register with the Plant Trips Committee in the Main Registration Booth in the Exhibit Lobby.

Message Center

A message center will be maintained by the Instrument Society of America during the conference and exhibit in the exhibit office immediately outside the Exhibit Hall. Lost and found service, message service and general information service will be handled here. Everyone is invited to make use of these services.

Foreign Visitors' Headquarters

Room 22, Stevens Hotel will be set up as the headquarters for foreign visitors during the conference.

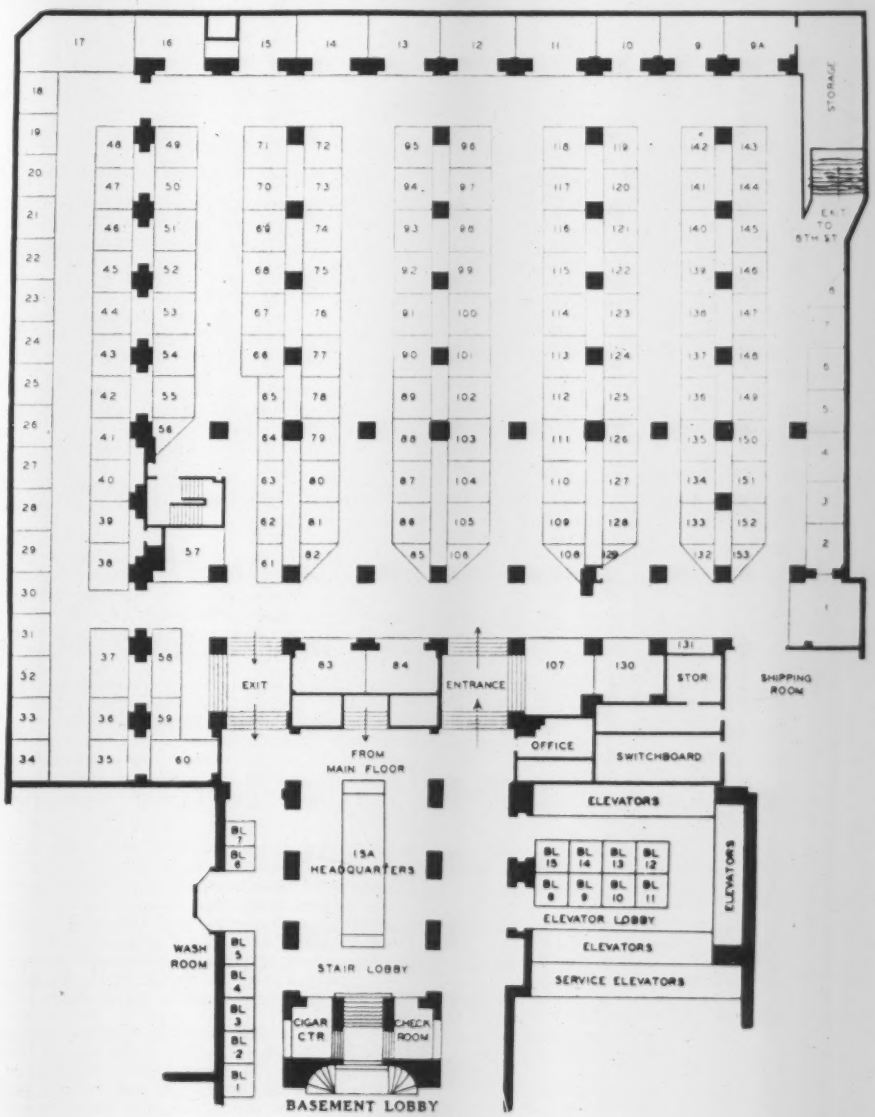
To Freshen Up

For the convenience of members and their guests arriving early for the convention, but unable to immediately obtain the use of their hotel accommodations, the Society has provided Room 22 to freshen up after your trip to the Conference.

Descriptive List of the Exhibits and Personnel in Attendance

EXHIBIT HOURS

Monday	**—12 noon to 6 p.m.**
Tuesday	**—12 noon to 10 p.m.**
Wednesday	**—12 noon to 6 p.m.**
Thursday	**—12 noon to 10 p.m.**
Friday	**—12 noon to 6 p.m.**



AEROQUIP CORP., 300 East Ave. S., Jackson, Michigan. Booth 79. *Exhibiting:* Hydrauliscope portable electronic analyzer to indicate and record hydraulic-system high-speed pressure phenomena; hose assemblies featuring detachable end fittings; self-sealing couplings. *In attendance:* Clarke Field, Manager Aircraft Sales; Howard Shireman, District Representative.

AIRCRAFT-MARINE PRODUCTS CO., INC., 1523 N. Fourth St., Harrisburg, Pa. Booth 104. *Exhibiting:* Automatic wire terminator; terminals, connectors, tooling. *In attendance:* E. G. Hefter, Raymond Dexter, Robert Graham.

A. S. ALOE CO., 1831 Olive St., St. Louis 3, Mo. Booth 53. *Exhibiting:* General line of laboratory apparatus including several new items. *In attendance:* Henry L. Ettman, V. P.; Don F. McCammond.

AMERICAN METER CO., 60 East 42nd St., New York 17, N. Y. Booth 83-84. *Exhibiting:* Controllers and regulators; Indicating, recording and integrating flowmeters; Flow Controllers; Orifice Meter; Wet and Dry Test Meters; Complete Line of pressure control regulators. *In attendance:* A. F. Benson, A. B. Cloud, C. B. Dushane, Jr., A. S. Chatfield, D. R. Cousland, Cade Clover, Wm. G. Hamilton, Jr., Wm. Kehoe, B. B. Gray, J. H. Satterwhite, Harold Wahl, Harry Shroyer, D. M. Thompson, L. H. Wise, D. C. Wiley, J. T. Pruitt, R. B. Wilmarth.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, 29 West 39th St., New York 18, N. Y. Booth BL-5. *Exhibiting:* Publication of the Society; Membership information and data on the A.S.M.E. *In attendance:* Headquarters Staff.

R. B. ANNIS CO., 1101 N. Delaware St., Indianapolis 2, Ind. Booth 41. *Exhibiting:* Model-M2 Dynograph Balancing Machine employing photoelectric scanning and cathode-ray tube indications. Split-core current transformers. *In attendance:* R. B. Annis, Pres.; R. W. Murphy and D. S. Dickey, Chicago Representatives.

ASKANIA REGULATOR CO., 240 E. Ontario St., Chicago 11, Ill. Booth 124, 125. *Exhibiting:* Newest developments in combined electronic, hydraulic, pneumatic controls; complete demonstrating unit for control by visitors; Pressure-flow regulators; Ratio-proportioning regulators; Electronic Servo Systems (remote control). *In attendance:* H. J. Velten, Pres.; H. Ziebolz, V. P. Engineering; C. E. Tweedle, Ass't to Pres.; Paul Glass, Research Engr.; W. W. Wheeler, Sales Mgr.; T. M. Lowe, Adv. Mgr.

ASSOCIATED RESEARCH, INC., 231 S. Green St., Chicago 7, Ill. Booth 42. *Exhibiting:* Morse Tester for testing parkway cables whether underground or otherwise; portable electronic Stroboscope; insulation resistance tester; ground resistance tester; insulation breakdown testers; lie detector; split-core current transformer for use with Model 601 voltammeter; current transformers; soil resistivity meters; limits bridge; hand tachometers; hand ohmeters. *In attendance:* James F. Inman, Pres., Diamond S. Dickey, Ralph W. Murphy, Representatives.

THE AUTOTRON CO., 128 West Main St., Danville, Illinois. Booth 65. *Exhibiting:* Specialty control units, Shadowcount, Shadowcontrol, Shadowmaster, Shadowswitch. *In attendance:* Werner A. Gieske, Pres.; Harper D. Roth, District Manager; G. Bruce Herrider, District Manager.

BAILEY METER CO., 1050 Ivanhoe Rd.; Cleveland 10, Ohio. Booths 108, 109, 110. *Exhibiting:* Area meter for metering viscuous or free-flowing fluids over a 50-to-1 flow-rate range; oxygen recorder employing catalytic combustion principle, second pen may record combustibles content if desired; Standardized Parts—eight basic components form over 100,000 electronic instrument and control combinations; resistance thermometers; potentiometer pyrometer; steam flow-air flow boiler meter; air-operated controls; electric controls; application engineering for instruments and controls. *In attendance:* H. M. Hammond, V. P.; P. S. Dickey, V. P.; E. B. Bossert, Adv. Mgr.; M. M. Barnett, Dist. Mgr.; R. V. Knapp, Dist. Mgr.; R. T. Cowan, Dist. Mgr.

BAIRD ASSOCIATES, INC., 33 University Road, Cambridge 38, Mass. Booth 72. *Exhibiting:* Industrial model continuously-recording infrared gas analyzer for production control; emission spectroscopy equipment; interferometer; Infrared spectroscopy equipment; surface temperature radiometer. *In attendance:* S. H. Walters, Mgr. Technical Sales; J. M. Devine, Sales Eng.

BARTON INSTRUMENT CO., 3500 Union Pacific Ave., Los Angeles 23, Cal. Booth 18. *Exhibiting:* Model 181 differential pressure indicator, rupture-proof bellows-actuated, ratings to 3000 lbs. calibrated from 50" WC to 200 lbs.; Models 163, 98, 157, 158, 167, 168. *In attendance:* Representatives of Nielsen & Fryer, Inc. of Chicago.

JAMES G. BIDDLE CO., 1316 Arch St., Philadelphia 7, Pa. Booth 118. *Exhibiting:* Megger insulation tester, rectifier operated, plug-in type; Murray Transformer Turn Ratio Test Set, portable for direct measurements of turn ratio in transformers; insulation testers; ground testers; direct-reading ohmmeters; low-resistance ohmmeters; tachometers; frequency meters; rheostats; hand tachometers and speed instruments; lamps. *In attendance:* Henry Eysenbach, Engr.; Stuart Sommer, Advtg.

BRANSON INSTRUMENTS, INC., Joe's Hill Road, Danbury, Conn. Booth 32. *Exhibiting:* "Audigage" Thickness Detector. *In attendance:* Peter K. Bloch, Norman G. Branson.

THE BRISTOL COMPANY, Waterbury 91, Conn. Booth 73-74. *Exhibiting:* Dynamaster resistance thermometer using null-balance principle for recording and controlling temperature between −150°F. and +400°F; Model C500 impulse sequence time-cycle controller for process operations; recording gages; recording thermometers; telemetering instruments. *In attendance:* H. E. Beane, Gen. Sales Mgr.; G. H. Gaites, Asst. Sales Mgr.; R. G. Tower, Dist. Mgr.

BROOKFIELD ENGINEERING LABORATORIES, INC. 2 Porter St., Stoughton, Mass. Booth 150. *Exhibiting:* Laboratory mixer featuring concentric oppositely-rotating shafts, speed 200 to 12000 RPM controlled by Variac; Automatic controlling viscometer, synchronous motor drive, rotational type, viscous drag balanced against spiral spring magnetic "chopper"; Synchro-Lectric Viscometer; Consulting, research, design and development. *In attendance:* W. B. Brookfield, President; G. W. Brookfield, Treas.; H. M. Chandler, Sales Mgr.

BROWN INSTRUMENT CO., Wayne & Roberts Aves., Philadelphia 44, Pa. Booths 50-51-52. *Exhibiting:* Elect-O-Vane thermometer providing continuous electric control new by-pass panel; rate response as tied in with temperature measurement; automatic standardization in conjunction with temperature measurement; recording integrating electric flow meter; multiple-record strip-chart Electronik resistance thermometer; multi-point indicating Electronik resistance thermometer; pneumatic flow receiver; single-record strip-chart Electronik pyrometer; pneumatic flow transmitter; pneumatic flow receiver with ratio control. *In attendance:* L. M. Morley, K. R. Knoblauch, W. H. Steinkamp, M. J. Ladden, A. O. Pearson, J. A. Robinson, C. E. Sharp.

THE BRUSH DEVELOPMENT CO., 3405 Perkins Ave., Cleveland 14, Ohio. Booths 2-3. *Exhibiting:* Contour analyzer compares unknown contours with master contours; stress-strain analyzer records strains from static to 100 cps., for use with Baldwin-Southwark wire strain gages; Model BL-913 d-c. amplifier with range of d-c. to 100 cps.; direct-inking oscillographs; surface analyzer; Vibration pick-ups. *In attendance:* M. P. Odell, Mgr. Instrument Dept.; H. A. Stearns, Instrument Dept.

BUFFALO METER CO., 2917 Main St., Buffalo 14, N. Y. Booth 127. *Exhibiting:* Meters: liquid, volumetric, water, hot water, oils and other liquids. *In attendance:* H. F. Barrett, Sales Mgr.

BUILDERS-PROVIDENCE, INC., 9 Codding St., Providence 1, R. I. Booth 39. *Exhibiting:* Chronoflo telemetering instruments; Shuntflo steam meter. *In attendance:* G. W. Kelsey, Gen. Sales Mgr.; W. W. Adams, Mgr. Engineered Products Sales.

BURGESS BATTERY CO., Freeport, Ill. Booth 90. *Exhibiting:* Manganese dioxide ores, highly active artificial dionides; dry batteries, thin magnesium strip; Engineering service on the design of batteries for special applications. *In attendance:* L. H. Harriss, Sales Mgr.; L. D. Foust, Sales Engr.

CALDWELL-CLEMENTS, INC., 480 Lexington Ave., New York 17, N. Y. Booth 59. *Exhibiting:* "Electronic Industries & Electronic Instrumentation" Display of editorial material and services in industrial electronic field. *In attendance:* Ralph F. Batcher, Executive Editor; Ben Morris, Promotion Manager; R. Y. Fitzpatrick, Western Mgr.; G. Gaskins, Western Sales Staff.

CARSON MICROMETER CORP., 2 East Main St., Little Falls, N. J. Booth 10. *Exhibiting:* Model M electronic micrometer accurate to 25 millionths on thin plastic film and sheet; Carson Electronic Micrometers including an improved diaphragm t[illegible] *In attendance:* R. W. Carson.

CENTRAL SCIENTIFIC CO[illegible] 1700 Irving Park Road, Chicago [illegible] Booth 26. *Exhibiting:* Titration-pl[illegible] meter can be used in grounded tanks; H[illegible] 25 pump with free air displacem[illegible] lpm. and ultimate vacuum well b[illegible] micron; De Khotinsky ovens; opt[illegible] sorption cells; new instruments an[illegible] ratus for industrial, educational an[illegible] cal laboratories. *In attendance:* L. [illegible] phy, R. P. Kellam.

CHICAGO METAL HOSE CORP[illegible] S. Third Ave., Maywood, Ill. Booth [illegible] *Exhibiting:* Fully-interlocked capillary [illegible] XH multiple-ply stainless steel b[illegible] large (up to 12") stainless steel b[illegible] various types of flexible metal hose, [illegible] and conduit. *In attendance:* J. F. [illegible] D. W. Fentress, A. S. Keller, E. W. Dried[illegible] ger, M. D. Thackaberry, G. G. Toepper, J. H. Ryan, R. M. Lindsay, L. M. Barenbrugge, G. D. Sweeney, D. E. Panzloff, W. K. Fawcett, H. L. Brown, K. H. Myers.

CLIMAX ENGINEERING COMPANY, 15 N. Cincinnati, Tulsa 1, Oklahoma. Booth 121. *Exhibiting:* Type 1400 pressure pilot 2015 and 2020 L. P. G. regulators; Types 1515, 86 and 15-DRT diaphragm-motor valve; Types 245 and 260 pressure-reducing regulator; Types 1455 and 1460 diaphragm valves; Type 995 time cycle controller; Type 850-1410 liquid-level control and pilot. *In attendance:* R. G. Thompson, James Dvoracek, Albert J. Hanssen.

CONCORD RADIO CORP., 901 W. Jackson Blvd., Chicago 7, Ill. Booth 21. *Exhibiting:* "Multiamp" system of amplification featuring plug-in units which permit increase in size of public-address system in an expanding industrial plant. *In attendance:* A. I. Rattray, Chief Engr., Irv. Litt Industrial Sales Mgr.

CONOFLOW CORPORATION, 2100 Arch St., Philadelphia 3, Pa. Booth 151. *Exhibiting:* Springless pneumatic diaphragm motor; diaphragm control valves for small flows, manual loading pressure regulators. *In attendance:* R. B. Werey, Pres.; M. M Watkins, V. P.; J. C. Koch, Sales Dept.

CONSOLIDATED ENGINEERING CORP., 620 W. Lake Ave., Pasadena 4, Cal. Booth 15. *Exhibiting:* Type 5-115 recording oscillograph records simultaneously 36 individual channels; static-dynamic measuring and recording System C for measurements of phenomena in range of 0 to 1000 cps.; Type 8-105 bridge for direct measurement of strains without amplifications vacuum leak detector; torsiograph; accelerometer; velocity pick-up; vibration meter

CONTINENTAL EQUIPMENT CO., 853 5th Ave., Coraopolis, Pa. Booth 93. *Exhibiting:* Butterfly Valves. *In attendance:* A. M. A. M. Capper, Pres.; John D. Hantz, V. P.; W. Hartman.

THE R. W. CRAMER CO., INC., Centerbrook, Conn. Booth 144. *Exhibiting:* New Model E panel-mounted synchronous-motor-operated interval timers, reset timers, time-delay relays, percentage timers and running-time meters; pulse timers; new Model F timers; Cramer Type Sx synchronous instrument motors; instrument chart drive motors, duplex cycle timer; multicontact timers; technical services. *In attendance:* R. W. Cramer, Alan DeCew, F .R. Brophy, Ray Ruddock, Grant Beverly.

DAVIS EMERGENCY EQUIPMENT CO. INSTRUMENT DIV., 80 Halleck St., Newark 4, N. J. Booth 136. *Exhibiting:* Micro-Gas Analyzer, portable or continuous with recorder; oxygen analyzer operating on paramagnetic qualities of oxygen; continuous flue gas analyzer built around Davis thermal conductivity cell operated directly in connection with a-c. recorder; continuous catalytic combustible gas alarm system thermal-conductivity gas analyzers. *In at-*

tendance: F. R. Davis, President; F. Taylor, Jr.; Gen. Mgr., Inst. Div.; F. J. Schirm, Ch. Eng.; G. G. Crewson, Jr., Chicago Rep.

DEHYDRAIRE CORPORATION, 14-13 118th St., College Point, N. Y. Booth 23. *Exhibiting:* Instrument Air Dehydraire (Drier). *In attendance:* Edwin W. Anders, V. P.; C. A. Chamberlain, Pres.; G. Baillie Houliston, Ohio Representative.

F. W. DWYER MFG. CO., 317 S. Western Avenue, Chicago 12, Ill. Booth 141. *Exhibiting:* Dwyer "Flex-Tube" manometers; plastic hook gage; inclined gages; CO_2 indicators, Pitot tubes. *In attendance:* F. W. Dwyer, J. G. Dwyer.

ELECTRO PRODUCTS LABORATORIES, INC., 549 W. Randolph St., Chicago 6, Ill. Booth 78. *Exhibiting:* Pressuregraph; Synchromaker; Synchronizer; detonation indicating equipment for measurement of static or dynamic pressures; Model A power supply; pressure-measuring equipment and associated electronic instruments. *In attendance:* D. Elam, W. O'Leary, W. J. Johnson, Harry Halinton, R. C. Crossley, A. Crossley.

ELECTRONIC DEVELOPMENT LAB., 2655 West 19th St., Chicago 8, Ill. Booth 44. *Exhibiting:* Oscilloscopes, audio oscillators, electronic switches, decade resistors and capacitors, precision bridges and potentiometers. *In attendance:* W. Schlesinger, F. Murphy, J. Dunlap, H. Neben, C. Richter.

ELLISON DRAFT GAGE CO., 214 W. Kinzie St., Chicago 10, Ill. Booth 6. *Exhibiting:* Inclined and vertical draft gages; pilot tubes; portable gas analyzers; straight-line diaphragm type; straight-line bell type; dial type gages; calorimeters. *In attendance:* Lewis M. Ellison, Pres.; Martin Coco, Sec'y.

ENGIS EQUIPMENT CO., 431 S. Dearborn St., Chicago 5, Ill. Booth 147. *Exhibiting:* Hyprez diamond compounds for quick lapping and polishing of instrument pivots, bearings and parts; Clinometers (angle indicating gages). *In attendance:* E. J. Schneider, V.P.; J. M. Throckmorton, Sales Engr.

EQUIPOISE CONTROLS, INC.; 100 Stevens Avenue, Mt. Vernon, N. Y. Booth 25. *Exhibiting:* Bimetal dial thermometers; separable sockets. *In attendance:* R. F. Coleman, Pres.; D. M. Nielsen and J. C. Fryer, Chicago representatives.

ESTERLINE-ANGUS CO., INC., P.O. Box 596, Indianapolis 6, Ind. Booth 41. *Exhibiting:* Recording wattmeter, ammeter and milliammeter; operation recorder; other recording instruments; current transformer, shunts, etc. *In attendance:* D. J. Angus, President; R. J. Kryter, Sales Mgr., A. J. Weber, Ch. Engr., W. H. Bollinger, Sales Engr., D. E. Brewer, Sales Engr., James Gall, Sales Engr., D. S. Dickey and R. W. Murphy, Chicago Representatives.

FISHER GOVERNOR CO., Marshalltown, Iowa. Booth 111, 112. *Exhibiting:* Dual Level-trol; new Design 249 Level-trol; integral Stellite seats; cast Stellite single-seated valves; Gismo small-volume D.M.V.; D.M.V. liquid-level controls; pressure-relay-operated controllers; lever valves; inner valves. *In attendance:* P. A. Elfers, V. P.; Lyle E. Eige, Ass't Sales Mgr.; G. F. Brockett, Ch. Engr.; T. B. Burris.

FISHER & PORTER CO., County Line Road, Hatboro, Pa. Booths 7, 8. *Exhibiting:* Automatic ratio-controller including a new chemical service diaphragm-motor valve; new capitance type Flow Alarm for use with variable flow meters; improved continuous viscosimeter; Rato-Tronic controls, records, totalizes flows as low as 1 cc/min.; Flowrator; Ratosight; Ratosleeve; sanitary flow-rate meter; laboratory flow-rate meter; precision-bore glass specialties; Rotameters. *In attendance:* Wm. A. Diament, V. P. & Sales Mgr.; G. Douglas Zimmerman, Robert E. Johnson, David P. Lupton, Pierre Charest, Edward Muhlheisen, Marvin Care, Frank King, Art Grazulius, Bruce Greaves, Harvey Krouse, John Larson, Sales Engineers.

FOXBORO COMPANY, Neponset Avenue, Foxboro, Mass. Booths 85, 86, 87. *Exhibiting:* New-design pneumatic transmitter for flow, pressure or temperature; differential pressure transmitter, mercuryless for pneumatic or electric operation; electronic recorder-controller; electric recorder and controller for resistance, humidity and strain measurements; control valves. *In attendance:* W. H. Kidd, Sales Mgr., Chem. Industries Div.; V. V. Tivy, Sales Mgr., Petroleum Ref. Industries, Div.; D. H. Fuller, Sales Mgr., Electronic Prod. Div.; J. J. Burnett, Div. Mgr., Central Div.; A. H. Shafer, Branch Mgr., Pittsburgh; E. B. Miller Branch Mgr., St. Louis; C. E. Hellenberg, Branch Mgr., Detroit; H. L. Lee, Branch Mgr., Cleveland; M. A. Schreiner, Sales Engr.; J. J. Connelly, Sales Engr.

THE FULTON SYLPHON CO., Knoxville 4, Tennessee. Booth 89. *Exhibiting:* Diesel engine safety controls, temperature regulators; bellows assemblies. *In attendance:* L. S. Dysart.

THE GAERTNER SCIENTIFIC CORP., 1201 Wrightwood Avenue, Chicago 14, Ill. Booth 9. *Exhibiting:* New toolmaker microscope; new automatic circular dividing machine; precision optical bench assembly; micrometer slides; comparators; cathetometers; filar micrometer microscopes; traveling microscopes; wave-length spectrometers; precision scales. *In attendance:* S. Jacobsohn, V. P. & Ch. Physicist; L. W. Higgins, Asst. to President; P. F. Meyn, Ch. Eng.; J. F. Zechmeister, Engr. in Charge of Dividing Machines; R. T. O'Connor, Adv. Mgr.

GENERAL ELECTRIC CO., Schenectady, N. Y. Booths 115, 116, 117. *Exhibiting:* Metals Comparator for quick non-destructive comparing of magnetic and non-magnetic metal parts that appear alike but differ in composition, heat treatment, porosity or hardness; new hand-held tachometer; spectrophotometer; dew-point recorder; strain-gage; viscosimeter; thickness gage; Luximeter; meters and instruments for measuring time, speed, temperature, light, magnetic strength, vacuum, position, liquid level, etc. *In attendance:* W. O. Hutchins, Mgr. Special Prod. Div.; H. Johnston, Laboratory Prod. Sec. of Special Prod. Div.; J. M. Whittenton, R. W. Kunkle, R. H. Mitchell, E. J. Boland; Sales Engrs.

GENERAL METERS & CONTROLS CO., 205 West Wacker Drive, Chicago 6, Ill. Booth 103. *Exhibiting:* New Oceco vacuum and pressure vents; new Farris nozzle type relief valve; Zallea improved dew equalizing expansion joint; Adsco condensation meter; Oceco tank gages; Zallea standard expansion joints; Farris standard relief valves. *In attendance:* H. P. Sunderland, J. A. Riggs, U. H. Stallings, C. W. Kimbrough, R. J. Kensting.

G-M LABORATORIES, 4300 No. Knox Ave., Chicago 41, Ill. Booth 44. *Exhibiting:* D'Arsonval galvanometers and G-M galvanometer relays. *In attendance:* Dr. Andrew Christy, Gerhardt Spiegel, Frank M. Maichle, Alfred P. Sirois.

CLAUD S. GORDON CO., 3000 S. Wallace St., Chicago 16, Ill. Booth 148. *Exhibiting:* Xactline "straight line" control; Gordon atmosphere indicator; Xactemp pyrometers, thermocouples; protecting tubes; insulators; extension lead wire; pyrometric supplies; pyrometer instrument repairs; industrial x-ray examinations. *In attendance:* C. S. Gordon, Pres., V. Manka, V.P.; A. W. Anderson, V.P.; W. Hammond, Asst. Dev. Engr.; R. O. Offill, Engr.; T. Christenson, Prod. Engr.; A. Kyle, Dev. Engr.; H. D. Burnside, Sales Engr.; G. A. Bosshart, Sales Engr., P. S. Doyle, Sales Engr., F. C. Mackey, Sales Engr.; F. C. Collins, Sales Engr.

GOTHAM INSTRUMENT CO., INC., 149 Wooster St., New York 12, N. Y. Booth 119. *Exhibiting:* Time-temperature recorder-controller housed in one case recording and controlling temperature in accordance with definite program; indicating, recording and controlling instruments for temperature and pressure. *In attendance:* Walter J. Halpern, Pres.; James P. Henderson, Gen. Mgr.; Robert Hamerschlag, V. P. Sales; Robert Hix, Reg. Mgr.

GOW-MAC INSTRUMENT CO., 22 Lawrence St., Newark 5, N. J. Booth 31. *Exhibiting:* Thermal conductivity units for gas analysis; Model MA automotive exhaust gas analyzer; Model RCC remote indicator; Model PA-M-2 Orsat saver. *In attendance:* James L. McFadden, Pres.; Wm. G. Gow, Vice Pres.; James A. McFadden, Sales Dept.

HAGAN CORP., RING BALANCE DIV., 323 Fourth Ave., Pittsburgh 30, Pa. Booth 1. *Exhibiting:* Flow meters; automatic combustion control mounted on panel; cut-away operating model of flow meter. *In attendance:* D. J. Erikson, R. R. Donaldson, Otto Vetter, D. O. Bean, M. J. Boho, G. W. Smith, M. S. Gare.

HAMMEL DAHL CO., 243 Richmond St., Providence 3, R. I. Booth 17. *Exhibiting:* Over-ratings display of control valves under actual operating conditions under extremely high pressure; Micro-Flow standard valves; Venturiflo valves; pressure loaded valves; Type 5000 pressure regulators. *In attendance:* E. T. Dahl, B. G. Woolley, D. Golner, Otto Kneisel, J. I. Fryer, D. W. Nielson, Harold Miller, B. A. Irwin, George Dahl.

HAYS CORPORATION, 742 E. 8th St., Michigan City, Ind. Booths 132, 133, 134. *Exhibiting:* Electronic type oxygen meter using paramagnetism principle; magnetic-clutch flow meter with float movement transmitted through pressure-type manometer by magnetic clutch; boiler efficiency meter; Hays Veriflow meter; automatic combustion control; flue gas analyzer; flow meters; draft gages; combustion instruments. *In attendance:* S. M. Rudolph, Sales Mgr.; W. H. Pugsley, Mgr. Engineering; Robert Richardson, Electronic Engr.; Geo. Bailey, Engr.; F. I. Lackens, Adv. Mgr.

H-B INSTRUMENT CO., 2518 N. Broad St., Philadelphia 32, Pa. Booth 28. *Exhibiting:* Sensitive mercury plunger relays for use directly with Red-top thermo-regulators, relay contacts hermetically sealed against dust and corrosion, silent in operation; engraved-stem thermometers; industrial type thermometers; mercury-in-glass thermostats; mercury-in-glass thermo-regulators; mercury plunger relays. *In attendance:* Valentine Hiergesell, Partner; John Sailor, Test Engr.; Charles G. Roveran, Production Mgr., George J. Duggan, Sales.

HELICOID GAGE DIV., AMERICAN CHAIN & CABLE CO., Bridgeport 2, Conn. Booth 129. *Exhibiting:* Helicoid gage with the Helicoid mechanism; pressure gages. *In attendance:* J. V. Tracy, Sales Mgr.; E. H. Grauel, Ch. Engr.

ILLINOIS TESTING LABORATORIES, INC., 420 N. LaSalle, Chicago 10, Ill. Booth 58. *Exhibiting:* Pyrometers; resistance thermometers; air velocity meters; dew-point instruments. *In attendance:* M. J. Rauscher, M. D. Carlson, N. Obermaier, J. J. Kuska, W. J. Bailey, A. Obermaier.

INDUSTRIAL INSTRUMENTS, INC., 156 Culver Ave., Jersey City, N. J. Booth 18. *Exhibiting:* Electrical measuring and test equipment for laboratory, shop and field use. *In attendance:* D. M. Nielsen, J. C. Fryer.

THE INSTITUTE OF RADIO ENGINEERS, INC., 1 East 79th Street, New York 21, N. Y. Booth BL6. *Exhibiting:* "Proceeding of the I.R.E." increased editorial features in the September issue; I.R.E. Yearbook; Standard reports; 1948

I.R.E. National Convention advance plans. *In attendance:* Wm. C. Copp, Adv. Mgr., J. Robert Marcett, Asst. Exhibit Mgr.

INSTRUMENT SOCIETY OF AMERICA, 1117 Wolfendale St., Pittsburgh 12, Pa. Booth 57. *Exhibiting:* Publications of the Society; Membership information and data on the I.S.A. *In attendance:* Committee Members, I.S.A.

INSTRUMENTS PUBLISHING CO., 1117 Wolfendale St., Pittsburgh 12, Pa. Booth 107. *Exhibiting: Instruments,* The Magazine of Measurement and Control; *The Instrument Maker,* the Trade Journal of the Industry; "Maintenance & Servicing of Electrical Instruments" by James Spencer; "Elementary Engineering Electronics" by Andrew Kramer; "Mechanical Measurements by Electrical Methods" by H. C. Roberts; "Instrumentation and Plant Design" reprint by F. H. Trapnell; "Requirement for an Instrument Department" reprint by William H. Fortney. *In attendance:* Richard Rimbach, Publisher; M. F. Behar, Editor; Richard Rimbach, Jr.; C. Goldcamp, Sales Manager; Harold Haskett, Chicago Manager; James Condon, New England Manager; Robert Farnham, New York Manager; Stuart Rogers, Philadelphia Manager; James Wright, St. Louis Manager; M. D. Pugh, West Coast Manager.

J-B-T INSTRUMENTS, INC., 441 Chapel Street, New Haven 8, Conn. Booth 81. *Exhibiting:* Model 50-50 cold zone tester with rotary selection switches with adjustable stops; pyrometers; appliance temperature testers; selector switches. *In attendance:* Roland M. Bixler, General Manager.

JERGUSON GAGE & VALVE CO., 87 Fellsway, Somerville 45, Mass. Booth 126. *Exhibiting:* Liquid level gage for 10000-lb. working pressure; Trulevel distant-reading boiler water gage; liquid level gages. *In attendance:* E. E. VanHam, Vice President; James A. Ford, Sales Mgr.

KIELEY & MUELLER, INC., 2013-33 43rd St., North Bergen, N. J. Booth 105-106. *Exhibiting:* Diaphragm-motor control valves featuring completely redesigned motor operators and valve bodies, wide rangeability of control, steel welded construction utilizing a clamp ring design to fasten upper and lower casings. *In attendance:* Clifford B. Ives, Robert J. Donnelly, C. W. Snyder, M. C. Waterman, Frank Bock.

LEEDS & NORTHRUP CO., 4901 Stenton Ave., Philadelphia 44, Pa. Booth 12. *Exhibiting:* Type G double-range indicator for rapid measuring of thermocouples; signalling controller for precise temperature control; Model S Type G indicating and recording controller for pneumatic control; Model R Type G indicating and recording controller, high-speed action with maximum visibility; new high-speed 25-ohm platinum Thermohm; Model S indicating recorder; Model S Type G eight-point indicating and recording controller; portable instruments for laboratory and plant checking; primary elements for temperature, conductivity, SO_2, pH, etc. *In attendance:* T. C. Bennett, Dist. Mgr. Ind. Sales Div.; N. Cohn, Dist. Mgr. Technical Sales Div.; L. E. Emerich, Mgr. Technical Sales Div.; A. E. Tarr, Mgr. Ind. Sales Div.; S. G. Flack, Engr. Cleveland; K. W. Maebius, Engr. Phila.; R. L. Wham, Engr. Chicago; E. R. Fiske, Jr., Adv. Div.

LESLIE COMPANY, Lyndhurst, N. J. Booth 101. *Exhibiting:* Single-seated diaphragm regulating valve for high-pressure drop; low-pressure temperature regulators; reducing valves; temperature regulators; pump governors; strainers; pressure controllers; steam heat and process steam; driers; fuel oil heaters; make-up systems. *In attendance:* T. W. Lietz.

LINDE AIR PRODUCTS CO., 30 East 42nd St., New York 17, N. Y. Booth 99. *Exhibiting:* Synthetic sapphire balls, spheres perfect within tolerances of less than 10 microinches; synthetic sapphire rods and rounds centerless ground and polished; Linde synthetic sapphire; ruby and spinel boule and rod; Linde fine alumina abrasives; engineering advice on present or anticipated uses for sapphire. *In attendance:* A. K. Seemann, E. O. Strauss, T. W. Eselgroth, J. J. Hock, Jr., Frank McGuire, Jr.; J. P. Skinner, P. T. McKinney, W. F. Hoffman Jr., C. H. Dougherty.

THE LIQUIDOMETER CORP., 41-03 36th St., Long Island City 1, N. Y. Booth 20. *Exhibiting:* Electric type remote-reading liquid-level gage; remote reading hydraulic transmission type liquid-level gage; remote-reading hydrostatic type liquid-level gage; direct-reading liquid-level gages. *In attendance:* H. T. Cullinan, V.P. and Sales Mgr.; Wallace R. Armstrong, Sales Dept.; W. P. Gossett, Sales Dept. for Chicago Representative.

MACBETH CORP., 227 W. 17th St., New York 11, N. Y. Booth 64. *Exhibiting:* Explosion-proof model pH Meter, continuous indicating, line-operated, recorder connections provided; pH Meter. *In attendance:* Frank G. Paully, Henry Herrmann.

MAGNETROL INC., DIV. OF FRED H. SCHAUB ENG. CO., INC., 2110 S. Marshall Blvd., Chicago 23, Ill. Booths 127, 128. *Exhibiting:* New magnetic switch mechanism in small flow switches and insertion type level switch for tanks containing all types of liquid; Boiler water level controls; float and float switches. *In attendance:* E. J. Snetsinger Sales Mgr., H. N. Stromquist, H. R. Hodgson, E. T. Eggelbrecht and B. L. Binford, Engineers.

MANNING, MAXWELL & MOORE, INC., 11 Elias St., Bridgeport 2, Conn. Booth 48. *Exhibiting:* Type 1172 Ashcroft chemical gage or services under corrosive conditions, protectors of tantalum, Hastelloy, lead, rubber, Monel or pure nickel; American snap action temperature limit regulator; Ashcroft thermal protector for protection against excess temperature, current failure, tube failure, breaking or burning-off of thermocouple; Duragauges, Ashcroft gages; American industrial thermometers; American dial thermometers; American recording thermometers; American temperature regulators; pulsation dampeners. *In attendance:* W. J. Cotter, (Sales Representatives) T. J. Naughton, C. F. Lane, D. A. Elert, H. G. Johnson;—(District Mgrs.) N. P. Selover, W. H. Bolin;—(Mgr. of Gauge Sales) E. M. Dederer;—(Mgr Instrument Sales) E. F. Nordstrom.

MASON-NEILAN REGULATOR CO., 1190 Adams St., Boston 24, Mass. Booth 11. *Exhibiting:* Valve positioner & position transmitter; displacement level controllers for duplex service; displacement level controllers; diaphragm control valves; indicating and recording pressure controllers; panel boards; regulators. *In attendance:* F. Kenneth Marrison, V. P.; Ralph A. Rockwell, Dir. of Engrg.; Paul Wing Jr., John L. Cronk, John W. Robins, Engrg. Dept.; Eric A. Bianchi, Boston Sales Engrg.; James M. McAlear, Mgr., Pulp and Paper Depts.; Gordon R. Thomason, Chicago Dist. Mgr.; Graham Davis, Chicago Sales Engr.; Clarence W. Wood, Philadelphia Dist. Mgr.; Richard J. Benson, Cleveland Dist. Mgr.; Edward J. O'Brien, St. Louis; D. J. Condit, Tulsa, Okla.; W. B. Rawson, Houston, Texas.

McGRAW-HILL PUBLISHING COMPANY, 330 W. 42nd St., New York 18, N. Y. Booth 22. *Exhibiting:* McGraw-Hill books; Monthly publication, *Electronics. In attendance:* Wallace B. Blood, Mgr., *Electronics;* Wm. W. MacDonald, Managing Editor, *Electronics.*

THE MERCOID CORP., 4201 Belmont Ave., Chicago 41, Ill. Booth 38. *Exhibiting:* Automatic Controls for temperature, pressure and liquid level. *In attendance:* H. Courteol, President; J. W. Owens, Ex. V. P.; W. L. Colterjohn, V. P.; A. S. Widdowfield, Sales Engr.; W. K. Stauffer, Mgr. Philadelphia; Wm. Ufer, Wm. Gearhart, V. L. Lischett, P. J. Provost, W. E. Jones, Sales.

THE MERIAM INSTRUMENT CO., 10920 Madison Avenue, Cleveland 2, Ohio. Booths 113, 114. *Exhibiting:* New manometer developments for measurements of pressure, vacuum or differential to exhibit micromanometers, dual-tube well-type manometers and absolute pressure gage; demonstration exhibit of inverted direct-reading well-type manometer principle in measurement of low flows using flowing fluids as indicating fluids; "U" type manometers, well type manometers; draft gage; indicating flow meters; sight feed bubblers; absolute pressure gages; mercury pressure gages; sediment traps; seal and condensate pots. *In attendance:* J. B. Meriam, Jr., Gen. Mgr.; Mark Meriam, Secretary; A. A. Hejduk, V. P.; P. B. Shaunon, Chicago Representative; C. F. Gast, St. Louis Representative; H. R. Bowers, Cleveland Representative.

MICRO METALLIC CORP., 193 Bradford Street, Brooklyn 7, N. Y. Booth 43. *Exhibiting:* Pressure snubbers to protect gages; instrument air filters; stainless steel filters for control of rate at which fluid enters or leaves gage; stainless steel bearings for high-temperature or corrosive conditions; stainless steel laboratory filters, gas spargers, industrial equipment. Fabrication of special equipment incorporating porous stainless steel sheet or moulded porous plugs. *In attendance:* David B. Pall, Pres.; Julian A. Lipman, Plant Mgr.

MINIATURE PRECISION BEARINGS CO., Keene, N. H., Booth 147. *Exhibiting:* Miniature precision ball bearings. *In attendance:* H. D. Gilbert, Treas.

MINE SAFETY APPLIANCES CO., Braddock, Thomas & Meade Sts., Pittsburgh 8, Pa. Booths 62, 63. *Exhibiting:* M.S.A. carbon monoxide and fire detector for aircraft; Explosimeter; hydrogen sulphide detector; methane detector; photoelectric vapor and gas analyzer; carbon monoxide indicator; oxygen indicator; multi-way sampling combustible gas indicator; methyl chloride detector; midget impinger; electrostatic dust and fume sampler microprojector; instruments for detecting, analyzing, and recording toxic and combustible gases for personal and plant protection and quality control. *In attendance:* N. W. Hartz, R. W. Keaton, Industrial Sales Dept.; F. F. Hahnfeldt, J. W. Ely, Sales Representatives.

THE J. W. MURPHY CO., 236 N. Clark St., Chicago 1, Ill. Booths 126-129, 132-135. *Exhibiting:* Products of Hays Corp., Penn Industrial Instrument Co., Helicoid Gage Div. of American Chain & Cable Co., Magnetrol Inc., Buffalo Meter Co., Jerguson Gage & Valve Co., Herman H. Sticht Co. (Products listed under individual companies in this program.) *In attendance:* C. B. Hovland, T. G. Robinson, O. H. Thelander, G. M. Palmer, G. W. Sayer, Roy Sahlstrom, G. Freundlick, E. A. Cook, R. D. Jenks.

MURPHY & DICKEY COMPANY, 537 So. Dearborn St., Chicago 5, Ill. Booth 41 and 42. *Exhibiting:* Products of Esterline Angus Co., and Associated Research, Inc. (Products listed under Esterline Angus Co. and Associated Research, Inc.) *In attendance:* D. S. Dickey, R. W. Murphy.

NATIONAL BUREAU OF STANDARDS, Washington 25, D. C. Booths 34-35. *Exhibiting:* Electronics in miniature; electronic micrometer; electronic viscosimeter; magnegage; linear flow meters; portable wind speed and direction indicator. *In attendance:* W. G. Brombacher, Ch. Mechanical Instruments Section; S. H. J. Womack, Aeronautical Engr.; M. L. Greenough, Assoc. Physicist; Hugh Odishaw, Ass't to the Director.

NAVAL ORDNANCE LAB., Naval Gun Factory, Washington 25, D. C. Booth 60. *Exhibiting:* Characteristic tube viewer; magnetic ordnance detector MK-3; portable seismograph and microbarograph; gyro sig-

nal generator and inclinometer. *In attendance:* K. G. Williams, B. H. Monish, E. R. Kolsrud, E. L. Deeter, C. C. Vogt, all N. O. L. Engineers.

NIELSEN & FRYER, INC., 152 East Superior St., Chicago 11, Ill. Booth 18. *Exhibiting:* Products of Barton Instrument Co. and Industrial Instruments, Inc. (Products listed under individual companies in this program.) *In attendance:* D. M. Nielsen, J. C. Fryer.

OFFICE, CHIEF OF ORDNANCE, U. S. ARMY, Pentagon Bldg., Washington 25, D. C. Booth 16. *Exhibiting:* Electronic computing fire control and ballistic measurement device. *In attendance:* Representatives of Chicago Ordnance District and Army Ordnance Association.

PALMER THERMOMETERS, INC., 2501 Norwood Avenue, Cincinnati 12, Ohio. Booth 77. *Exhibiting:* Industrial indicating thermometers featuring new extruded case; mercury-actuated dials and recorders; industrial thermometers; mercury dials & recorders. *In attendance:* Bartlett Palmer, Pres.; Frank W. Probst, Pl. Mgr.; D. Hitt, Sales Dept. H. R. Bowers, Carl Gast, Dist. Representatives.

PARAGON ELECTRIC CO., Two Rivers, Wis. Booth 94. *Exhibiting:* Automatic time controls. *In attendance:* Wm. C. Leff, David Douglass, Read W. Eldred.

PENN INDUSTRIAL INSTRUMENT CORP., 3116 N. 17th Street, Philadelphia 32, Pa. Booth 135. *Exhibiting:* Penn Rotameters: electric flow meters; magnetic clutch mechanical flow meters; temperature and pressure recorders and recorder-controller. *In attendance:* W. C. Bennett, Pres. & Gen. Mgr.; Wm. Melas, V. P. & Ch. Engr.; Kenneth C. Markley, V. P. & Works Mgr.; D. J. Kamalo, Inst. Eng.

PERMO, INC., 6415 Ravenwood Ave., Chicago 26, Ill. Booth 153. *Exhibiting:* Permopivots. *In attendance:* E. C. Steffins, V. P. and Gen. Mgr.; S. E. Pate, Mgr. Permopivot Div.

THE PERMUTIT CO., 330 W. 42nd St., New York 1, N. Y. Booth 102. *Exhibiting:* Ranarex portable CO_2 meter; Ranarex specific gravity meter; Ranarex exhaust gas analyzer; Ranarex furnace atmosphere analyzer; Ranarex gas analysis instruments for special purposes. *In attendance:* F. D. Harper, F. M. Jones.

PHILADELPHIA SECTION, INSTRUMENT SOCIETY OF AMERICA, Clarence W. Wood, 6908 Market St., Upper Darby, Pa. Booth BL-3. *Exhibiting:* Floor plan of The 1948 Instrument Conference and Exhibit; information on Philadelphia. *In attendance:* Members of the Philadelphia Section, I.S.A.

PHOTOSWITCH, INC., 77 Broadway, Cambridge 42, Mass. Booth 55. *Exhibiting:* Photoelectric Counter Set PL; electronic Timer Type 30 HLi, time intervals from 1/20 second to 4 minutes; Electric Level Control Type 10 CB1, no floats or moving parts in tank, contact with liquid made by stainless steel probe rods; Fireye Combustion Control Systems, protection against explosions caused by flame failure or dangerously low water level. Industrial photoelectric controls; Photoelectric registration controls; Electronic timers; Electric level controls; Liquid interface controls; Smoke alarms and indicators; Electronic pilot relays; Fireye low water cut-off and boiler feedwater controls; Development and production of photoelectric and electronic controls to meet special specifications. *In attendance:* John Long, Executive V.P.; Larry Sibley, Equip. Sales Mgr. Phillip Mann, Mid-West Sales Mgr.

PHYSICISTS RESEARCH CO., 321 South Main Street, Ann Arbor, Mich. Booth 137. *Exhibiting:* Proficorder shop instrument for making profiles of surface showing roughness and waviness; Profilometer for inspection of surface roughness. *In attendance:* Fred J. Engelke and Frank W. Rabat, field representatives.

PLUMMER & KERSHAW, 2757 Frankford Ave., Philadelphia 34, Pa. Booth 9A. *Exhibiting:* Optical systems, design & manufacture. *In attendance:* John L. Plummer, Partner; Dr. D. H. Rank, Design Engr.

POMEROY STEREOGRAPH COMPANY, INC., 1783 E. 11th Street, Cleveland 14, Ohio. Booth 24. *Exhibiting:* Perspective-drawing machine producing perspectives without vanishing points, grids, outriggings, or other accessories; plots straight lines, curves, ellipses, and contours in true perspectives; will produce Stereopairs. *In attendance:* Jos. Hirshstein, George N. Newman, Harold Heuser.

PRECISION THERMOMETER AND INSTRUMENT CO., 1434 Brandywine St., Philadelphia 30, Pa. Booth 142. *Exhibiting:* Dial thermometers—complete series 4" dial bimetal-actuated from 100° through 850°F.; industrial type thermoregulator; density indicator and control; laboratory thermometers; mercurial barometers; hygrometers; industrial thermometers; mercurial altitude standards; mercurial vacuum gages; thermoregulators; manometers; Mercurial pressure gages; psychrometers. *In attendance:* W. D. Laverell, V. P.

PRECISION TUBE CO., 3828 Terrace St., Philadelphia 28, Pa. Booth 40. *Exhibiting:* Radio contact pins for plug-in type connectors; metal shielded wire; Bourdon tubing; seamless tubing in copper, brass, aluminum, nickel and non-ferrous alloys in sizes 3/8" OD to 0.010" OD × 0.001" wall; engineering assistance and application information. *In attendance:* Norman H. Jack, Jr., Prod. Mgr.; Alfred J. Armstrong, Prod. Supervisor; Charles T. Flachbarth, Ch. Eng., Chester S. Pondo, Metallurgist.

PRODUCTION INSTRUMENT CO., 710 W. Jackson Blvd., Chicago 6, Ill. Booth 138. *Exhibiting:* Panelmount electric counters; mechanical and electrical counting devices; predetermined electric counters for automatic batch control; centralized production counting; actuating switches; electric-eye counting. *In attendance:* J. F. Visin V.P.; M. L. Nelson, Ch. Engr.; J. L. Jedd, Eng.; B. E. Harvery, G. G. Herrider, Sales Representatives.

THE REFINERY SUPPLY CO., 621 E. 4th St., Tulsa 3, Oklahoma. Booth 29. *Exhibiting:* Smoke meters; improved gas gravity balance; improved gas gravitometers; oil and gas testing, recording, controlling and indicating devices; engineering services. *In attendance:* W. A. Schlueter, Pres.; A. W. Chandler, Prod. Engr.; H. F. Goodenough, Research Engr.; J. B. Okeson, Mgr.

REPUBLIC FLOW METERS CO., 2240 Diversey Parkway, Chicago 47, Ill. Booth 152. *Exhibiting:* Boiler control panel including boiler meter, draft gage and master controller; electric flow meter; pneumatic transmitters for flow, pressure, liquid level and density; regulators for pressure, flow and liquid level. *In attendance:* S. C. Vail, District Mgr., Chicago; H. R. Kessler, District Mgr., New York; L. C. Walter, District Mgr., Philadelphia; S. B. DeCamp, W. E. Eckdhal, A. Heuring, Sales Engineers.

ROLLER-SMITH, 1756 W. Market St., Bethlehem, Pa. Booth 143. *Exhibiting:* Electrical indicating instruments—panel, switchboard and portable types; precision balances; rotary switches; instrument relays. *In attendance:* E. S. Maury, Mgr. Instrument Sales; A. Keich, Sales Engineer.

ROWE RADIO RESEARCH LABORATORY CO., 2422 N. Pulaski Rd., Chicago 39, Ill. Booths 49, 71. *Exhibiting:* MW 55 VHF milliwattmeter; PCR 16 precision iso-current regulators; PS 40 10 KV iso-volt power supply; Tel-O-Buz; synchro-cyclic timers; oscillograph accessory apparatus; milliseconds measurement apparatus; precision apparatus; engineering service. *In attendance:* H. C. Rowe, Pres. & Dir. of Engrg.; R. P. Faust, Dir. of Sales Engrg.; S. C. Kohl, Business Mgr.; D. V. Sinninger, Ch. Engr.; W. Parisoe, A. A. Gerlach, J. M. Lomasney, V. L. Brown, R. W. Timmer, P. Shafer, Engineers.

R-S PRODUCTS CORP., 4530 Germantown Ave., Philadelphia 44, Pa. Booth 69. *Exhibiting:* Control and shut-off valves. *In attendance:* D. W. Hopkins, V. P.; R. C. Ayers.

SARCO COMPANY, INC., 475 Fifth Avenue, N. Y. 17, N. Y. Booth 80. *Exhibiting:* New temperature, pressure and liquid level controls based on hydroelectric valve operator; open-and-shut and full-throttling proportioning controllers; steam traps of the thermostatic, float-thermostatic, liquid-expansion and inverted-bucket types; pipe-line strainers; self-operated temperature regulators; heating specialties for steam and hot water; engineering service. *In attendance:* G. B. Burke, V. P.; C. E. Brackenridge, R. L. Stewart, R. Rosevear, E. G. Avery.

SCHUTTE KOERTING CO., 12th and Thompson Sts., Philadelphia 22, Pa. Booth 120. *Exhibiting:* Electronic flow control for low flow using electronic circuit for alarm signals for extremely small flow-rates; electronic recording Rotameter; high-pressure Rotameter; Universal Rotameter; by-pass Rotameter; induction alarm Rotameter; panel-mounted Rotameter; chemical and instrument engineering consultation service. *In attendance:* S. G. Ketterer, Chemical Eng.; H. W. Gripton, Engineer.

SCOTT ELECTROFLUX CO., 400 Main St., Waltham 54, Mass. Booth 33. *Exhibiting:* New Electronic Thickness Gauge for the non-destructive measurement of metallic vessels, plates, tubes, etc. when one side only is accessible. *In attendance:* G. T. Brady, Gen. Mgr.; R. C. Scott, Chief Engr.; C. H. Colburn, Asst. Gen. Mgr.; H. K. Mackechnie, Asst. Ch. Engr.

SEEDBURO EQUIPMENT CO., 618-626 W. Jackson Blvd., Chicago 6, Ill. Booth 19. *Exhibiting:* Steinlite electronic moisture tester for testing many materials within moisture range from 2% to 40%. *In attendance:* L. W. Faulkner, Dir. Sales Devlpt. & Research.

SEELY INSTRUMENT CO., INC., 377 Fourth St., Niagara Falls, N. Y. Booth 27. *Exhibiting:* Model ECN program controller for almost unlimited process sequences or coordination; Model DT-6 time cycle controllers for pneumatic, electrical or combination control actuation; Series 136 dual-position hydraulic control valve, diaphragm-operated, two regulating adjustments per valve throttle, normal flow up to 3500 lbs.; Model PB2 time cycle controller; Model PC 2-3 pressure controllers; Series 105-106 two-pressure hydraulic operating valves. *In attendance:* A. M. Patterson, Jr., Pres.; G. C. Butler, V. P. & Gen. Mgr.; D. A. Weger, Chic. Branch Mgr.; J. B. Brill, Indianapolis Agent.

SHALLCROSS MANUFACTURING CO., Jackson & Pusey Aves., Collingdale, Pa. Booth 146. *Exhibiting:* Low-resistance test sets; combined Kelvin-Wheatstone bridges; broadcasting station equipment controls; fixed and variable multi-range test sets; decade resistance boxes; kilovoltmeters; resistance standards rotary selector switches; accurate & precision resistors. *In attendance:* D. H. Shallcross, Gen. Mgr.; J. S. Shallcross, Sales Engr.; Dewees H. Shallcross, Jr., Engr.; Charles H. Fritz, Sales Engr.

SHURITE METERS, 611 Hamilton Street, New Haven 8, Conn. Booth 81. *Exhibiting:* Pocket meters for hearing aid batteries; small panel instruments; voltmeters; ammeters; milliammeters; resistance meters. *In attendance:* B. W. Heuvelman, Sales Engr.; J. C. West, Sales Engineer.

SIMPLEX VALVE AND METER CO., 68th and Upland Sts., Philadelphia 42, Pa. Booth 102. *Exhibiting:* Type "S" parabolic flume meter permits accurate measurement

under low-head conditions, will operate accurately when submerged; Type "S" parabolic flume. *In attendance:* Everett M. Jones, V. P.; Frank E. Gerlitz, Jr., Sales Mgr.

SIMPSON ELECTRIC CO., 5200-18 W. Kinzie St., Chicago 44, Ill. Booths 75, 76. *Exhibiting:* Portable tester with roll top carrying case; electrical laboratory incorporating a complete set of a-c. & d-c. instruments; complete line of electrical and electronic service instruments; complete line of a-c. and d-c. panel instruments. *In attendance:* G. H. Koch, Sales Mgr.; J. T. Keeney, R. T. Brown, Sales Dept.; H. A. Bernreuter, Ch. Engr.; W. B. Coon, Engr. Dept.

SORENSON & CO., INC., 375 Fairfield Ave., Stamford, Conn. Booth 56. *Exhibiting:* New Model 150 a-c. line voltage regulator; Model 250S and Model 500 a-c. line voltage regulators; Nobatron d-c. voltage source. *In attendance:* Edward R. McCarthy, Mgr. Eng. Sales; Alfred Crossley, Representative.

SOUTH BEND LATHE WORKS, 425 E. Madison St., South Bend 22, Ind. Booth 70. *Exhibiting:* 8187-ZN 10" × 3½' 1" collet capacity precision toolroom bench lathe; 344ZN 9" × 3½' precision lathe. *In attendance:* C. L. Miller, Engineering Consultant; R. W. Planck, Sales Dept.

THE STANDARD ELECTRIC TIME CO., 89 Logan St., Springfield 2, Mass. Booth 95. *Exhibiting:* Precision timers; tachometers; Chrono-tachometers; jacks, plugs; special connectors. *In attendance:* E. S. White, Asst. Sales Mgr.; F. P. Foley, W. H. Niemann, Chicago Sales.

HERMAN H. STICHT CO., 27 Park Place, N. Y. 7, N. Y. Booth 126. *Exhibiting:* Model B-7 Megohmer insulation tester; megohmer insulation testers; tachometers, portable and stationary types; rheostats; electrical testing instruments. *In attendance:* A. H. Volker, Gen. Mgr.

THE SUPERIOR ELECTRIC CO., 83 Laurel St., Bristol, Conn. Booth 96. *Exhibiting:* Stabiline type instantaneous electronic voltage regulator; Superior binding post; Powerstat variable transformers; Stabiline type electromechanical voltage regulators; Voltbox a-c. power supplies.

THE SURTY MFG. CO., INC., 4139 W. Kinzie St., Chicago 24, Ill. Booth 88. *Exhibiting:* Magnifying units for inspection of output or incoming materials; safety equipment; technical engineering service. *In attendance:* H. W. Beegle, Mgr.; K. L. Barron, E. E. Kock, Engineers.

C. J. TAGLIABUE MFG. CO., 540 Park Ave., Brooklyn 5, N. Y. Booth 14. *Exhibiting:* Industrial thermometers; oil testing instruments; chemical thermometers; hydrometers; pyrometers — indicating, recording and controlling; air-operated non-indicating, indicating and recording controllers; recording thermometers; pressure gages; dial indicating thermometers. *In attendance:* Ernest Wacker, Gen. Mgr.; George Koening, Gen. Sales Mgr.; George Sloane, Dist. Mgr. Chicago; Chris Stafford, Dist. Mgr. St. Louis; Ralph Staub, Dist. Mgr. Cincinnati; F. L. Frock, Dist. Mgr. Cleveland.

TAYLOR INSTRUMENT COMPANIES, 95 Ames Street, Rochester 1, N. Y. Booths 66, 67, 68. *Exhibiting:* Transet controller, new pneumatic transmission system; square root integrator, new principle of operation; liquid level transmitter, force-balance device to measure level of viscous or corrosive liquid and liquids containing solids; Fulscope controller; 86R controller; self-acting controller; industrial thermometers; automatic-manual control unit; aneroid manometer; pneumatic transmitter; time schedule controller; pneumatic set controller; floating scale manometer; dial type receiver gage. *In attendance:* R. E. Olson, F. S. Ward, J. S. Detwiler, A. J. Fleig, R. E. Clarridge, G. E. Heller, R. Pond, W. W. Lockwood.

TELECHRON, INC., Ashland, Mass. Booth 54. *Exhibiting:* C52 and E11 timers; advertising clocks: H20 motor; synchronous motors; movements and timers. *In attendance:* Carl B. Dix, John H. MacLeod.

THWING-ALBERT INSTRUMENT CO., Penn St. and Pulaski Ave., Philadelphia 44, Pa. Booth BL-7. *Exhibiting:* Direct-reading moisture meter; Model 3041 pyrometer with indicator and 2" to 24" point switch; Model 3 pH meter; M-33 pyrometer switch; pyrometer accessories; Elmendorf tearing tester; Clark softness-stiffness tester; Currier size tester; pH meter; A5X pyrometer; "Treasure Chest"; J-R Diesel pyrometer; portable radiation pyrometer; Model 3043 pyrometer; utility pyrometer kit. *In attendance:* E. J. Albert, Treas.; Ralph E. Green, F. W. Eitzel, Sales Engineers.

H. O. TRERICE CO., 1420 Lafayette Blvd., Detroit 16, Michigan. Booth 4. *Exhibiting:* Thermometers; temperature regulators; pressure regulators; gages; steam traps; air filters. *In attendance:* A. J. Clattner, Chicago Branch Mgr.; F. Z. Dahn, Ass't Sales Mgr.; J. L. Brackett, Ch. Engr.

TRIMOUNT INSTRUMENT CO., 37 W. Van Buren St., Chicago 5, Ill. Booth 140. *Exhibiting:* Manometers; flow meters; liquid level gages. *In attendance:* J. L. Mayer, Pres.; E. Kreml, Sec.; E. Knorring, P. Jayes, J. Cotter, Sales Representatives.

TRINITY EQUIPMENT CORP., 605 Broad St., Newark 2, N. J. Booth 61. *Exhibiting:* Latest design of solid drilled thermowells; thermocouple wells; thermometer test wells; separable sockets for thermometers; pyrometer protecting tubes. *In attendance:* George R. Feeley, Pres.; James V. Maunion, V. P. in Charge Mfr.

THE TRIPLETT ELECTRICAL INSTRUMENT CO., Harmon Road, Bluffton, Ohio. Booth 81. *Exhibiting:* New Models 625-NA, 666 HH, 3413, 3432, 3433, 3480, 3286 of volt-ohm-milliammeters, tube testers and signal generators; "Little Tripletts" electrical instruments; vacuum-tube voltmeters; panel and portable instruments; appliance testers. *In attendance:* W. R. Triplett, V. P.; M. M. Triplett, V. P. Engrg.; N. A. Triplett, Sales Mgr.; C. J. Sheridan, Sales Engr.; J. C. West, B. W. Heuvelman, Chicago Representatives.

UEHLING INSTRUMENT CO., 473 Getty Ave., Paterson, N. J. Booth 98. *Exhibiting:* Absolute pressure indicator; absolute pressure recorder; liquid level indicator; vacuum indicator; pressure gages; pressure & vacuum gages; draft gages; mercurial barometer; vacuum recorder; manometers.

VEEDER-ROOT, INC., 70 Sargeant St., Hartford, Conn. Booth 130. *Exhibiting:* New and special types of counting devices developed during the past year; various types of standard counting and computing devices. *In attendance:* C. C. Lombardi, Chicago Mgr.; E. C. Britton, Chief, Sales Engineering; J. R. Mathieson, Div. Sales Supervisor.

VERNON-BENSHOFF CO., 933 Ridge Ave., Pittsburgh, Pa. Booth 47. *Exhibiting:* Mountings in transparent-acrylic resins for product presentation: immobilization in water-clear plastic for display and protection of objects which are small, fragile or subject to corrosion; "exploded" presentation of small mechanisms; cut-away display of internal arrangement of complex articles without danger of derangement of parts. *In attendance:* Ida M. Harman, Research Dept.; E. M. Savage, Edward S. Wright, Sales Representatives.

THE VICTOREEN INSTRUMENT CO., 5806 Hough Avenue, Cleveland 3, Ohio. Booths 91, 92. *Exhibiting:* Geiger-Mueller counting systems, new-design scale-of-64 featuring built-in 2000-volt power supply with extremely close voltage regulation; portable Geiger-Mueller counting systems equipped with headphones for field surveys; subminiature electrometer tubes; radiation measuring instruments; high megohm resistors (100 to 10 000 000 megohms). *In attendance:* D. C. Collins, Dir. Tech. Service; E. A. Benson, V. P.; J. A. Victoreen, Pres.; M. Bevis, Laboratory Director.

WALKER-JIMIESON, INC., 311 West Ern Ave., Chicago 12, Ill. Booth 149. *Exhibiting:* New Hickok Model 209 electrical volt-ohm-milliammeter; instruments by Hickok Jackson, Dumont, Shallcross, RCA Precision, Triplett and Simpson; service to electrical plants on electronic test equipment. *In attendance:* V. T. Peterson, Inc. Sales Mgr.; Ed Heims, Karl Schaeffer, Sales Representatives.

WALLACE AND TIERNAN PRODUCTS INC., 1 Main St., Belleville 9, N. J. Booth 30. *Exhibiting:* Precision pressure-sensitive instruments for research, production, exploration, surveying, etc. *In attendance:* L. E. Denler; W. H. Haring, Mgr. Instrument Sales.

WEATHER BUREAU, U. S. DEPT. OF COMMERCE, Washington 25, D. C. Booth 145. *Exhibiting:* Altimeter-setting indicators; various pressure-measuring instruments employed by the Weather Bureau. *In attendance:* R. E. L. Blumenauer.

WEKSLER THERMOMETER CORP., 32 W. Houston St., New York 12, N. Y. Booths 45, 46. *Exhibiting:* Industrial thermometers; glass indicating type; laboratory thermometers and hygrometers; dial indicating and recording thermometers; dial indicating and recording pressure gages; recording thermometers with temperature and time-of-operation feature and, in connection with this instrument, a running time meter.

W. M. WELCH MFG. CO., 1515 Sedgwick St., Chicago 14, Illinois. Booth 100. *Exhibiting:* Electrical measuring instruments; vacuum pumps; stainless steel balances; atomic weight chart. *In attendance:* J. Gutsmiedly, Pump Sales; R. C. Hoffman Meter Sales.

WESTON ELECTRICAL INSTRUMENT CORP., 614 Frelinghuysen Ave., Newark 5, N. J. Booth 139. *Exhibiting:* Humidity indicator; Model 769 electronic analyzer; Model 877 photographic analyzer; electrical measuring instruments; industrial and laboratory testing thermometers. *In attendance:* R. T. Pierce, Larry Parachini, L. C. Nichols.

WHEELCO INSTRUMENTS CO., 847 W. Harrison St., Chicago 7, Illinois. Booths 122, 123. *Exhibiting:* Capacilog indicator-recorder; electronic panelmount Capacitrol featuring interchangeable sub-assembly and component part arrangement; new Wheaton solenoid valve for gas, oil, air, and water; Electrolink which provides an electronic link between measurement and control functions; pyrometer controllers; combustion safeguards; portable pyrometers; portable potentiometers. *In attendance:* Fred A. Hansen, Pres.; Chas. L. Saunders, Exec. V. P.; Claude A. Gates, V. P.; Clarke H. Joy, V. P.; R. A. Schoenfeld, V. P.; K. W. Day, Sales Engr.; H. W. Bluethe, Adv. Mgr.; B. Ramthun, Sales Engr.; R. N. Miller, Service Engr.; J. C. Freyberg, Asst. Adv. Mgr.; R. B. Meredith, Engr.; M. A. Embertson, Sales Engr.

THE H. A. WILSON CO., 105 Chestnut St., Newark 5, N. J. Booth 97. *Exhibiting:* Ni-Span C, new age-hardening constant-modulus alloy; contacts—silver, platinum, tungsten, alloys, sintered powder metal; thermostatic bimetal; silver clad steel Jacketed wire; rolled gold plate and wire; special materials. *In attendance:* Marshall Ward, Special Alloys Div.; Judson Strong, Adv. Mgr.; C. Tappan, Mgr. Chicago.

JOHN WORLEY JEWEL CO., Waltham 54, Mass. Booth 131. *Exhibiting:* Jewel instrument bearings; sapphire orifices; wire and thread guides; sapphire wear parts. *In attendance:* Donald F. Worley, Pres.; Members of The Sittler Co., Chicago Representatives.

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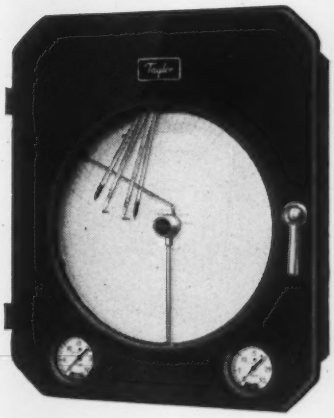

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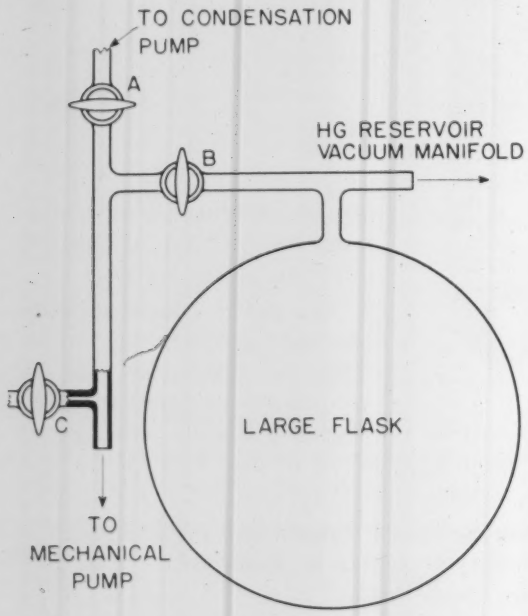
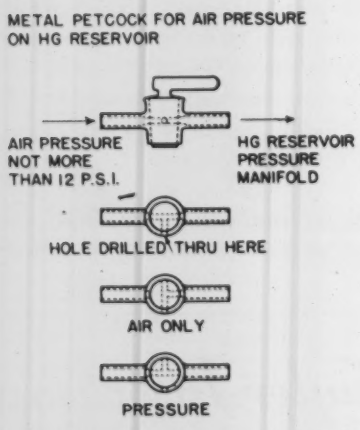
By WILLIAM E. BARR and VICTOR J. ANHORN, Gulf Research & Development Company

XII. GAS ADSORPTION APPARATUS FOR MEASURING SURFACE AREAS *(continued)*

VARIOUS REFINEMENTS *(continued)*

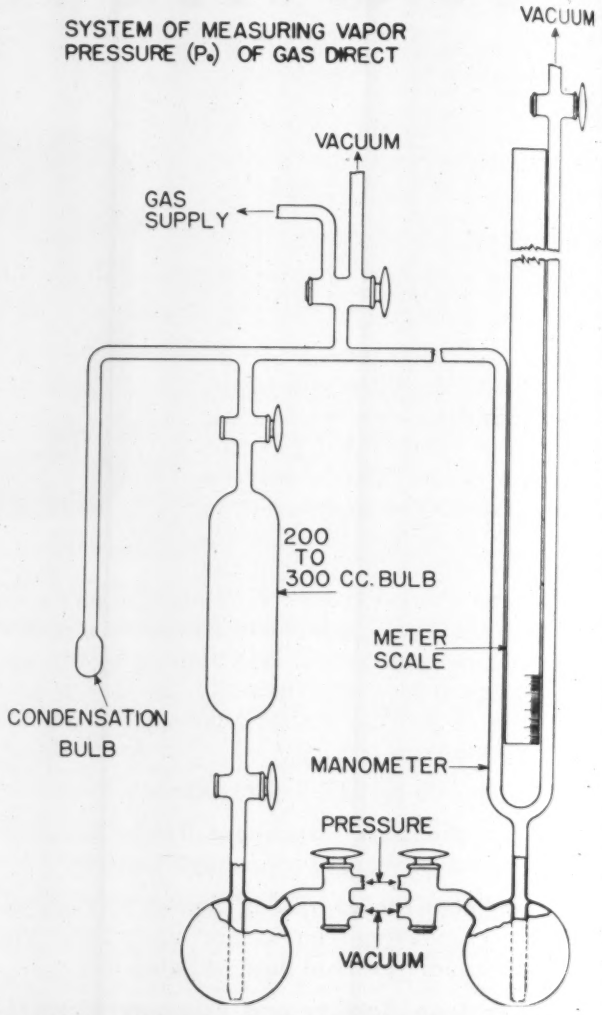
Although a simple aspirator pump is perfectly satisfactory for applying vacuum to the mercury reservoirs it is often quite annoying. Attaching a large flask or other vacuum tight vessel of at least 20-liter capacity to the vacuum side is a convenient method of maintaining a vacuum for the mercury system. This vacuum reservoir must of course be periodically pumped. This can be done by either the forepump or a separate pump if one is available. Fig. 161 shows a system where the forepump is being used for this purpose. This arrangement has the advantage that when the system is first being evacuated of air by keeping stopcocks *A* and *B* open, the pressure on both surfaces of the mercury is kept the same. When the system is under high vacuum stopcock *A* should never be open when the tank is being evacuated through *B*. A reduction valve and a petcock bored as shown in Fig. 162 solves the problem of easily changing from atmospheric to higher pressures on the pressure side of the mercury reservoirs.




METAL PETCOCK FOR AIR PRESSURE ON HG RESERVOIR
AIR PRESSURE NOT MORE THAN 12 P.S.I.
HG RESERVOIR PRESSURE MANIFOLD
HOLE DRILLED THRU HERE
AIR ONLY
PRESSURE

A second source of error in the apparatus as first described is in the determination of P_0 from the oxygen vapor pressure thermometer. Since this involves three steps, determination of the vapor pressure of the oxygen, plus the need of two tables either or both of which may be in error, two of these steps may be eliminated by measuring the vapor pressure of nitrogen directly. A system for doing this is shown in Fig. 163.

One of the most awkward bits of manipulation and the source of possible error is in the setting of the pressure leg of the manometer on the zero reference point. As the apparatus was described this had to be done by adjusting the pressure over the mercury in the reservoir. A fine capillary tube and stopcock attached to the reservoir, through which air can be slowly admitted, enables one to slowly raise the mercury to the reference point. This however has the disadvantage that it will work only in one direction. The incorporation of two devices solves the entire problem. The first is a fine adjustment control to adjust the mercury level and the second is a contact indicator located at the reference point.



The fine adjustment control is shown in Fig. 164. A side arm is sealed to the reservoir above the mercury level. Six to eight inches of a medium-weight rubber tubing is attached to side arm so that it extends 5″ to 6″ beyond the side arm. The open end of the tube is then closed with a rubber plug and sealed so as to be vacuum-tight. By squeezing this rubber tube with a clamp the volume of the

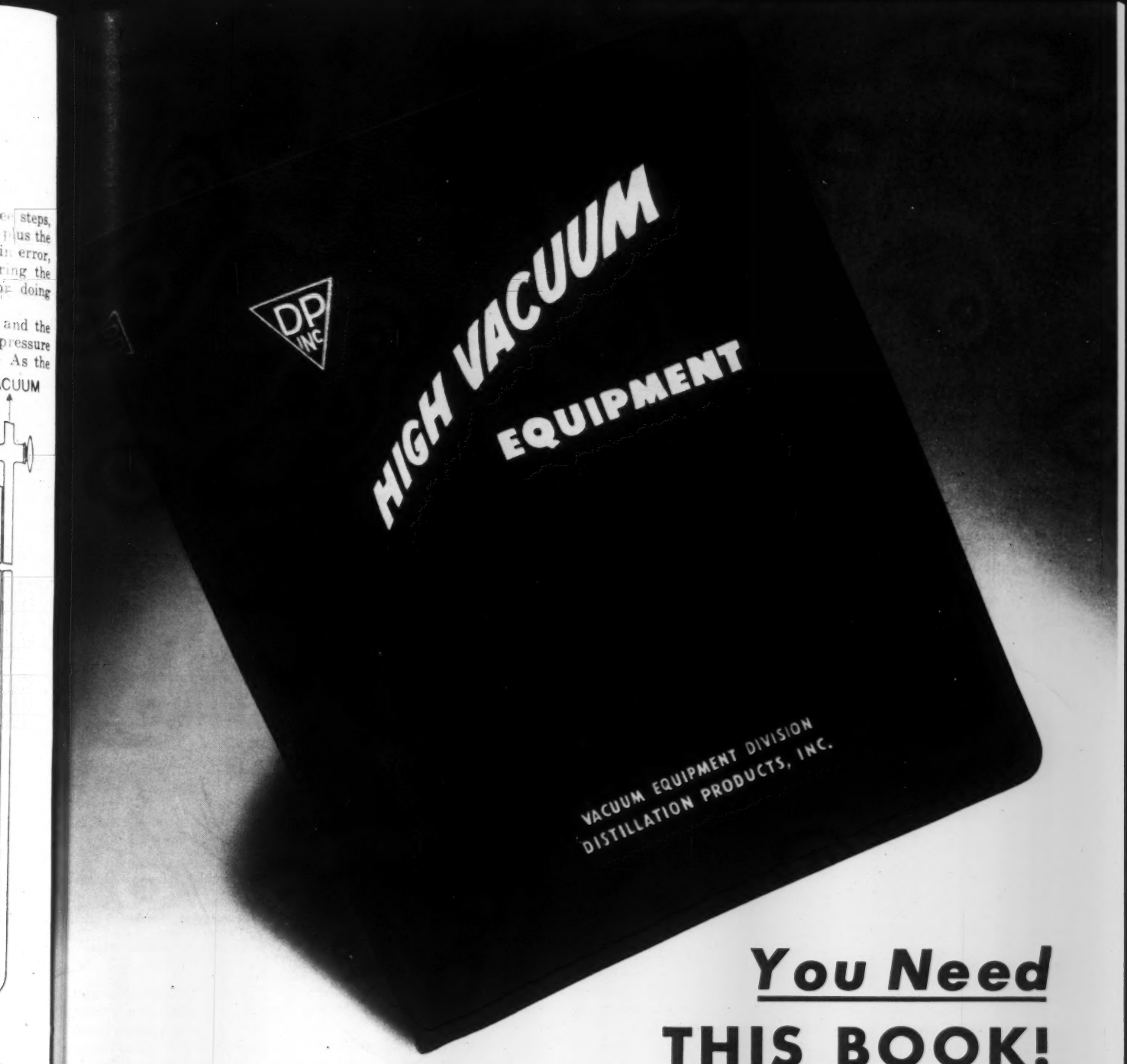


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Fig. 164

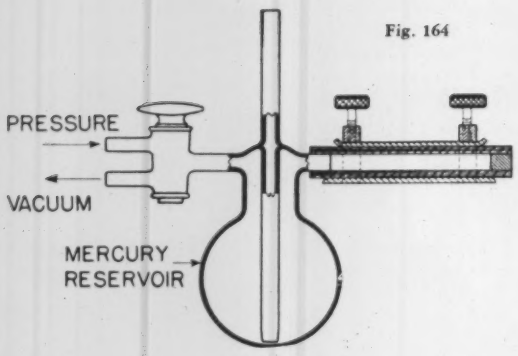
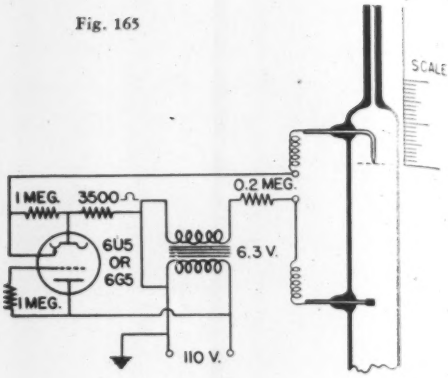


Fig. 165



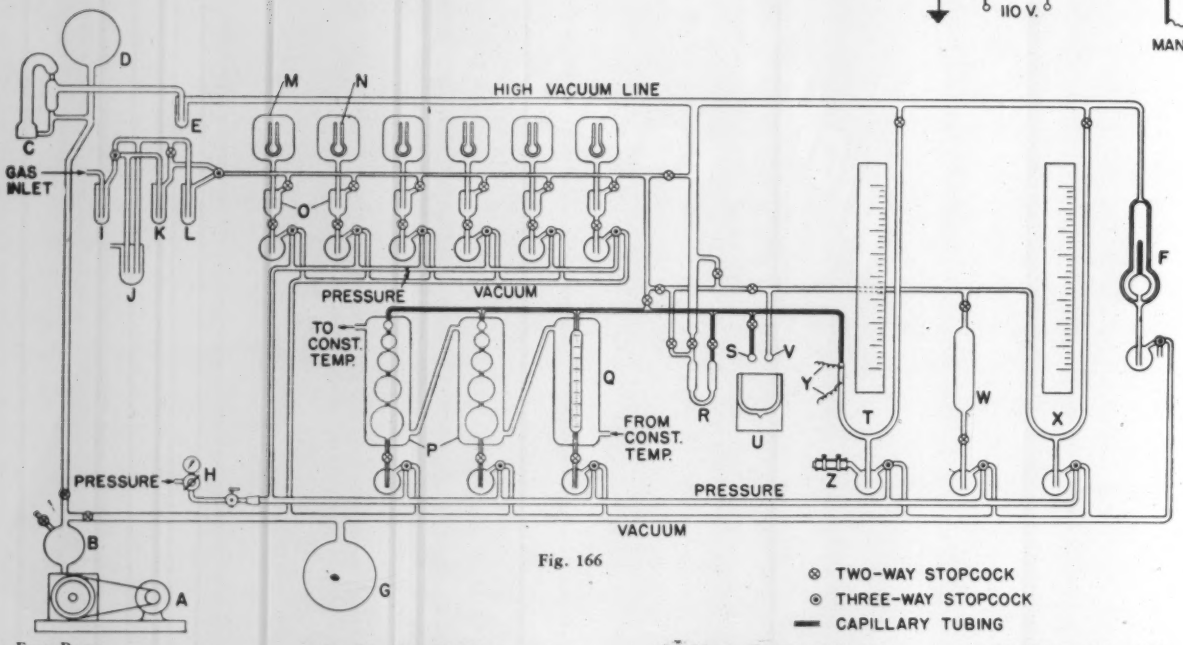


Fig. 166

⊗ TWO-WAY STOPCOCK
⊙ THREE-WAY STOPCOCK
— CAPILLARY TUBING

A—Fore Pump
B—Oil Trap
C—Mercury Diffusion Pump
D—Fore Vacuum Reservoir
E—Liquid Nitrogen Trap
F—McLeod Gage
G—Vacuum Reservoir
H—Pressure Regulator and Petcock Release
I —Trap (Reduced copper turnings —hot) to Remove Oxygen
J —Overflow Bubbler
K—Trap (Glass beads—liquid N_2) to dry
L—Trap (Activated charcoal—liquid N_2) to Purify Helium
M—Gas Reservoirs
N—Indicating Manometers
O—Mercury Cut-offs
P—Bulb Burettes with Constant-temperature Jacket
Q—Linear Burette (10 ml.)
R—Micromanometer
S—Adsorption Bulb
T—Manometer for Adsorption System
U—Dewar Flask
V—Vapor-pressure Bulb
W—Compression Bulb for Vapor Pressure
X—Vapor Pressure Manometer
Y—Contacts for "Electric Eye" Indicator
Z—Fine Adjustment Clamp
A-F—Vacuum System
G-H—Mercury Reservoir Control System
I-O—Gas Purification and Storage
P-U—Adsorption System
V-X—Vapor Pressure System
Y-Z—Devices for Setting Manometer on Zero

air space in the reservoir is altered, with a corresponding small change in the mercury level. Also shown in Fig. 164 is a wide clamp which is useful for squeezing the rubber tube. The operation is simple. With the clamp open the mercury is adjusted roughly to 5 mm. below the reference point by means of the vacuum-pressure stopcock. The stopcock is then closed and the clamp on the rubber tube tightened: this raises the mercury slowly to the reference point. Since by loosening the clamp the mercury can be lowered, it does not matter if the reference point is overshot in the first attempt. The success of the device depends upon the rubber tubing used. We have found that tubing ¼" ID, ⅛" wall, is most suitable. The rubber should not be too stiff or it makes it difficult to operate the adjustment screw. Tubing made of gum rubber is probably the best type.

Obviously any error in setting the mercury on the reference point of the manometer causes an error in the pressure reading. A mirror placed in back of the reference mark helps to avoid parallax in setting the position of the mercury. A meter engraved on a mirror makes an excellent manometer. Such a scale can be purchased from the Scientific Glass Apparatus Company. However, any visual reference point is subject to error and it is also a serious strain on the eyes. A simple electrical contact indicator sensitive to 0.01 mm. was described by Mills[5] and has been used with complete satisfaction. The indicator consists of a tungsten pointer sealed through the manometer and used as the reference point. When mercury touches the pointer it completes a circuit between the pointer and a wire sealed through the manometer wall into the mercury. This circuit operates the grid of an "electric eye" indicator tube. As long as the mercury is out of contact with the pointer, i.e., below the reference point, the eye is open but as soon as contact is made the eye closes. The mercury is considered to be on the reference point when a very slight turn of the fine adjustment control causes the eye to close. Fig. 165 shows a circuit for such an indicator. The pointer can be made by sealing an L-shaped piece of tungsten wire through the wall of the manometer with the point downward as shown in Fig. 165. The point should be as close to the center line of the manometer tube as possible. With continued use the point of the contact occasionally becomes contaminated. It can be easily cleaned, however, by evacuating the manometer and touching the point of a Tesla coil to the outer end of the contact pointer. The lead wires should first be disconnected so as to avoid damaging the "electric eye" tube.

A gas adsorption apparatus may be used for many purposes other than the determination of the area of a solid, but no attempt has been made to describe such uses or to describe modifications which would adapt the apparatus to particular purposes. To do so would be much too involved

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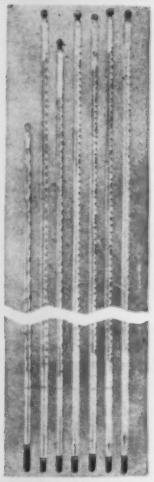

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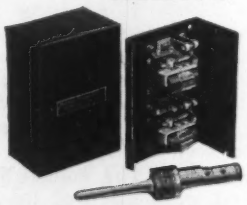

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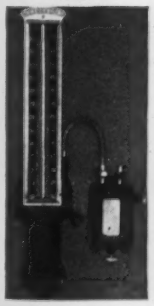

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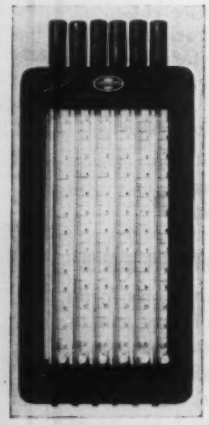

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for the present purpose. However, an apparatus can be designed to incorporate several features which make it adaptable for various types of adsorption studies. A brief description of some of the features of one such unit used at the Mellon Institute may be of interest.

Since the apparatus was to be a permanent piece of equipment in the laboratory, it was designed so as to have as high a degree of precision as possible. It was desired to have an apparatus which would be capable of measuring both low pressures (0.01 to 1 mm.) and pressures close to the saturation value, i.e., close to P_0, with as good precision as the intermediate pressure. It was also desirable to utilize gases other than nitrogen. A flow diagram of this apparatus is shown in Fig. 166.

The apparatus was mounted an a rack six feet wide and reaching to the ceiling. The base of the rack consisted of a table 14" high and 34" wide. Two 2" pipes which extended from the table to the ceiling were rigidly fastened at the center of the ends of the table. The cross pieces of the rack consisted of 1" angle iron fastened between the two pipes at intervals of 12". Uprights of ½" rod were fastened to the cross pieces and at the bottom to the table. All units of the apparatus were then attached to the cross pieces of the rack by using special clamps, Fig. 139. The arrangement of this compact and permanent installation on the rack is shown in Fig. 167.

In order to improve the precision of the pressure readings, a special manometer stand was used with a vernier reader capable of reading to 0.1 mm. This in conjunction with the "electric eye" indicator for the reference point makes very precise pressure readings possible.

To obtain a more detailed adsorption isotherm, it is necessary to make readings at frequent pressure intervals. This requires that a large variety of burette volumes should be available. Consequently a second burette, similar to the one described but with six small bulbs ranging from 5- to 30-cc. capacity, was added to the system. A linear burette of 10-cc. capacity was also used. This burette was made by putting a water jacket on a Pyrex (774) 10-cc. burette (graduated to 0.05 cc.) with the stopcock removed and capillary tubing sealed to the ends. A calibration reference mark was made on the capillary tubing on the end attached to the adsorption system. When not in use the mercury is always kept at this mark to avoid any volume error that might be caused if one tries to keep the mercury at a point in the wider portion of the burette. The volume between this scratch mark and the first graduation of the burette

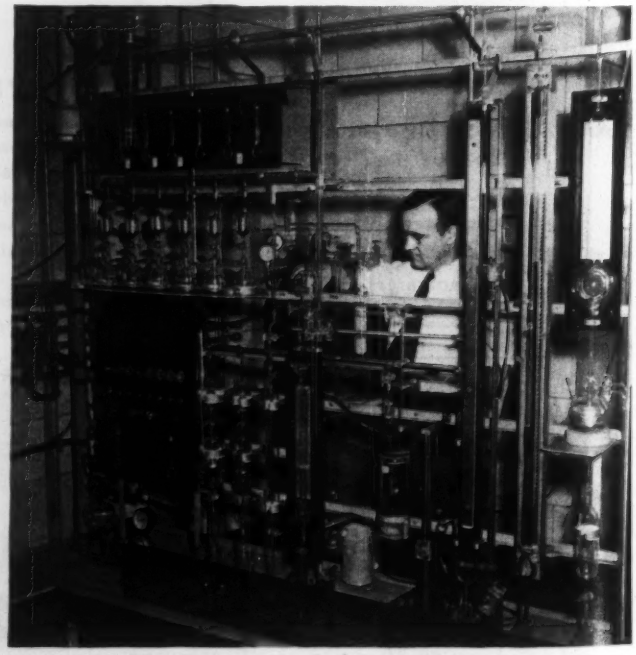

Fig. 167

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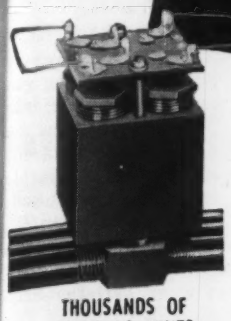

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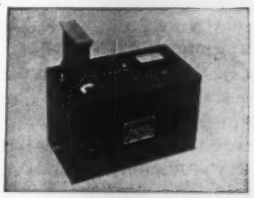

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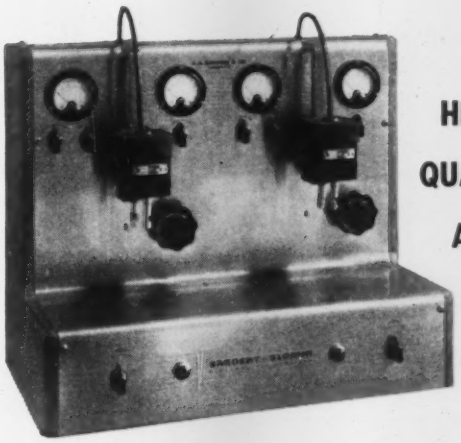

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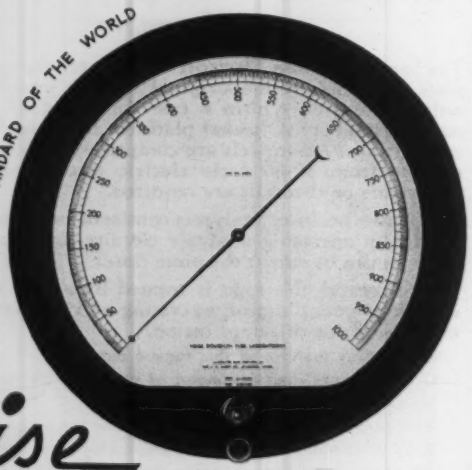

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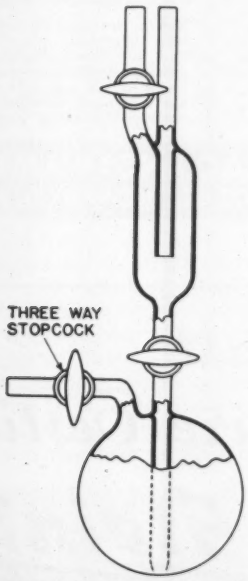
was calibrated with mercury before the burette was attached to the system. The arrangement of the three jacketed burettes is shown in Figs. 166 and 167.

In order to keep the temperature fluctuations at a minimum, liquid from a constant-temperature bath was circulated through all three of the burette jackets.

Since gases other than nitrogen and helium are used for adsorption studies, six gas storage bulbs were incorporated into the apparatus. Some of these gases dissolve readily in the stopcock grease and hence it is necessary to place a mercury cut-off between the storage bulb and the stopcock to the gas manifold of the system. A convenient and suitable type of cut-off is shown in the Fig. 168. When the cut-off is open the mercury is kept just below the end of the tube from the gas storage bulb. To close it, the mercury is raised in the cut-off up to the upper stopcock which is then closed. In this state there is no possibility of the gas coming into contact with the stopcock nor of air leaking into the storage bulb and contaminating the gas. To open the cut-off again the mercury is lowered. As the mercury drops the pressure in the storage bulb causes the gas to bubble through the mercury into the uppor portion of the cut-off. This frees any mercury which may have remained in the short length of tubing below the upper stopcock, if this tubing has a sufficiently large inside diameter. As indicated, 8-mm. tubing has been found to work satisfactorily. The location of the mercury cut-off valves is shown in Fig. 166.

Fig. 168



With such a cut-off it is perfectly safe to store the gas at pressures of an atmosphere or less since there is no danger of air contamination through a leaky stopcock. This arrangement allows the use of a unique type of manometer only 6" long as an indicator of the amount of gas present in the storage bulb. This is an ordinary 6" closed-end "U" type manometer. Some gas is allowed to remain above the mercury in the closed end. To fill such a manometer, mercury sufficient to half fill the "U" tube is poured into the open end without evacuation. The excess air trapped in the closed end is then slowly pumped out through the mercury. When as much gas as possible has been pumped out, the vacuum may be released and another half inch of mercury added to the open end of the manometer. The position of the mercury in the closed end should be noted and a mark placed on the glass at this point. This indicates approximately one atmosphere. By pumping on the open end with an ordinary manometer in series with the pump the position of the mercury in the closed end may be noted and marked for various fractions of an atmosphere. The advantage of this type of indicator is that it takes up much less space than a full-length open-end manometer and consequently may be mounted quite compactly on a panel board as illustrated in Fig. 167. The six indicating

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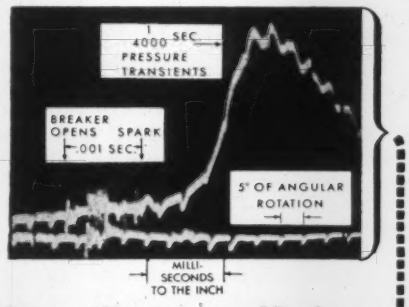

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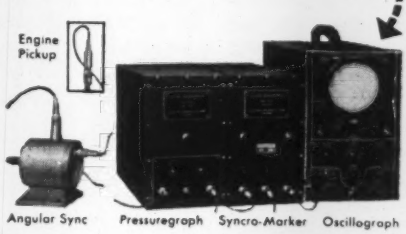

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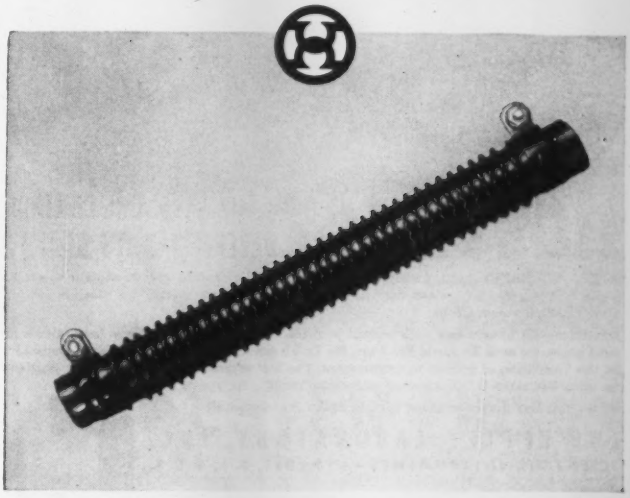

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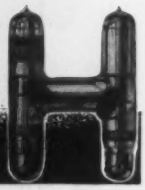

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manometers were located on the panel above the mercury cut-off valves, Fig. 166.

One of the purposes for which this particular apparatus was designed was to be able to measure accurately pressures as low as 0.01 mm. as well as relative pressures very close to unity. Both of these objectives were attained by using a short large-diameter manometer which is read by means of a sliding microscope cathetometer capable of being read to 0.001 mm. Constant-bore tubing (0.9851" ID) was used for the two legs of this manometer. Figs. 167 and 169 show how this can be incorporated into the system. To read the low pressures the left arm is opened to the vacuum through stopcock B (C closed). The difference in the mercury levels then give the pressure directly. To measure pressures close to saturation the left arm is opened through stopcock C to the vapor pressure line. Hence the mercury level difference is a measure of $P_0 - P$. P_0 is read from the vapor-pressure manometer and the pressure of the system is determined by the difference.

Since the volume of the right arm of the manometer must be known accurately, the point of a needle fastened to the manometer is used as a reference mark. The volume between the stopcock A and this reference point was first determined by the same method as has been described for the

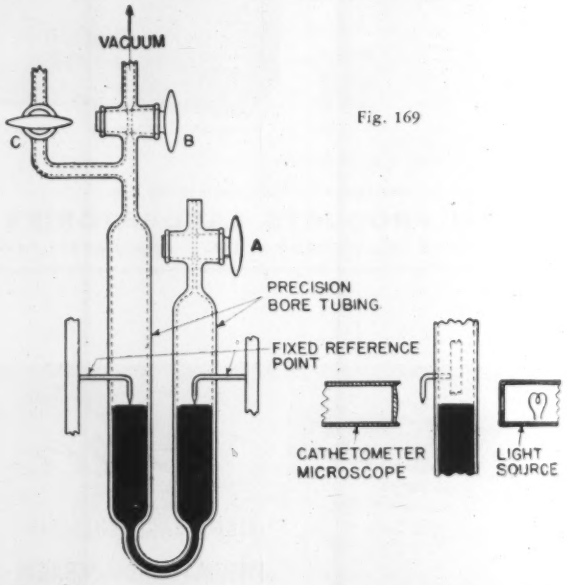

Fig. 169

determination of the capillary portion of the adsorption system. The mercury was maintained at the reference point by adjusting the pressure in the left side. Since the manometer was made of tubing with a known constant bore, the volume from the reference point to the mercury can be calculated. This value is added to the volume up to the reference point. The use of constant-bore tubing also eliminates any capillary effects on the meniscus if the tubing is perfectly clean.

Although the microscope cathetometer is capable of reading to 0.001 mm., it is hardly possible to read the mercury level this accurately, unless very great care is taken to eliminate all vibration and to use a source of parallel light to illuminate the mercury column.

With an apparatus as complicated as this and which was designed to be of a permanent nature, it was necessary and worth while to have all electrical, water and pressure controls located on a panel board. A sliding stand was designed so that the furnace and liquid nitrogen bath could be moved easily into place about the adsorption bulb without danger to the system. Protecting frames made from ½" expanded metal were placed about those portions of the apparatus which are in danger of being accidentally broken. All these features were used in the apparatus shown in Fig. 167.

5. B. Mills, *Review of Scientific Instruments*, Vol. 12, 1941, page 105.

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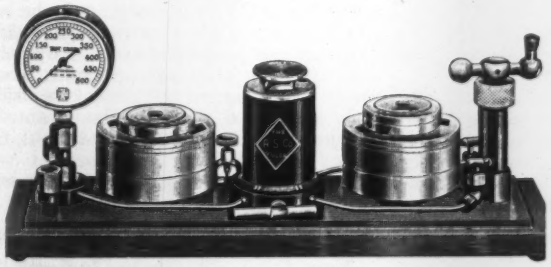

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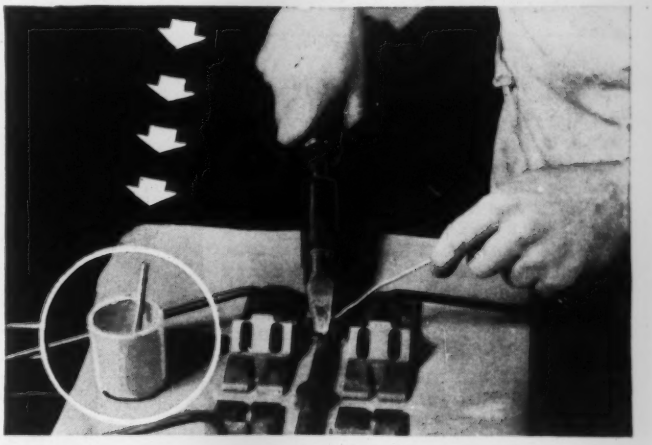

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Temperature-time-resistance Type Time-delay Relay

New "Chronotron" is a rate-sensitive and time-control device mounted in an ordinary miniature-vacuum-tube envelope with seven pins. (EDITOR'S NOTE. Instead of using photo we have drawn diagrams.) It should be of special value in electronic control circuits when a rate factor and time delay are needed. It is already being used in critical instrumentation, such as servo system of maker's automatic landing approach for aircraft, and in maker's automatic steering system for marine craft. It can be used to replace certain unreliable circuit components, as well as certain mechanical devices. Basic principle of "Chronotron" is thermal conductance of an insulator interposed between heater winding and secondary winding (see Fig. 1). Secondaries are resistance wires, with a positive temperature coefficient of resistivity, connected in a bridge circuit. A difference in heater currents causes a difference in the secondary-winding temperatures, unbalancing the bridge and giving rise to an output voltage. Rate of increase in output voltage, and hence heating and cooling characteristic times or "time-constants" (see Fig. 2) depends on factory choice of insulator (dimensions, thermal diffusivity, etc.). "Chronotrons" are available with characteristic times from several seconds to two minutes. "Chronotron" is unaffected by large variations in ambient temperature and humidity. Its small size offers space and weight advantages. Since no part operates at excessively high temperatures, it has practically unlimited life.—*Eclipse-Pioneer Div., Bendix Aviation Corp., Teterboro, N. J.*

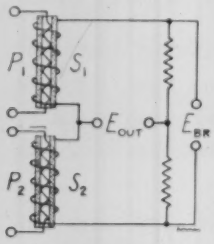


Fig. 1

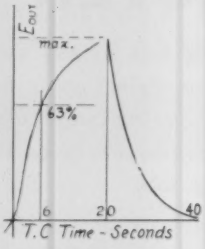
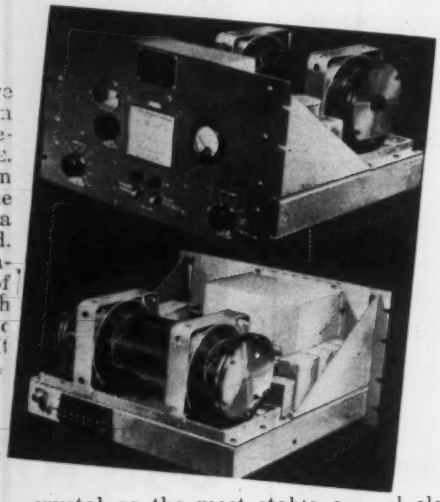


Fig. 2

Please mention number **801** when filling out card

Frequency Standard

New "Model D-175730 Primary Frequency Standard" provides a frequency of 100 kc., accurate to one part in 100 million per day. It may be used with frequency dividers to drive a clock: with its rate held constant by compensation for aging of crystal, it measures time to an accuracy of one second in three years. It employs a "GT" cut

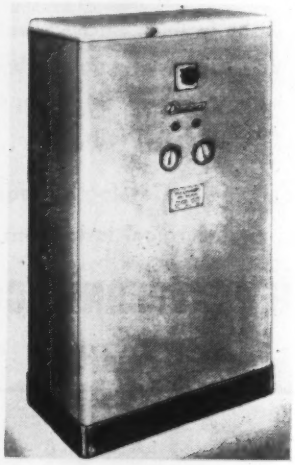


crystal as the most stable crystal element, with relative freedom from temperature effects. Aging rate of these crystals is accurately known, and compensating adjustments are provided. Instrument combines this type of crystal, a highly-stabilized bridge oscillator circuit, and an electrically-controlled heater which holds crystal temperature constant to 0.01°. Crystal is suspended by a series of wires inside an evacuated glass envelope. This envelope is inserted into a copper cylinder, upon which is wound temperature-sensitive bridge of electronically-controlled heater. To minimize heat loss, this assembly is mounted inside a glass Thermos flask, enclosed in a second copper cylinder which is closed and upon which is wound the coarse heater coils. Surrounding these coils is a layer of heat insulation and a plated outer housing. Entire assembly is cradled in rubber pads. Shock-insulated oven assembly is mounted on a chassis 19" deep on which the electronic equipment is assembled. Chassis is attached to a control panel 19" wide and 10½" high. Entire unit weighs 90 lbs. and is suitable for standard relay rack mounting. It requires current supplies capable of furnishing 115-volts a.c., 6.3-volts a.c. and regulated 135-volts d.c.—*Western Electric Co., 195 Broadway, New York 7, N. Y.*

Please mention number **802** when filling out card

Air-drying Units for Pneumatic Instrumentation

New "Dehydraire" line of instrument air dryers is announced, with capacity of 12½ to 250 scfm. at 100-lb. pressure and 70°F., which will dry air for 25 to 500 air-operated instrument installations. Air leaving unit will have a final dew point as low as −60°F., assuring absolute dryness regardless of weather conditions. Dryers are available for either single or polyphase reactivation or steam reactivation where steam pressures of 100 lbs. or over are available. Units for handling 25 to 100 instruments are totally enclosed cabinet models. Units for 150 to 500 instruments are of open tower design with front operating panel. Units are available for either manual or automatic reversal on an 8-hour cycle. For refineries or other hazardous locations

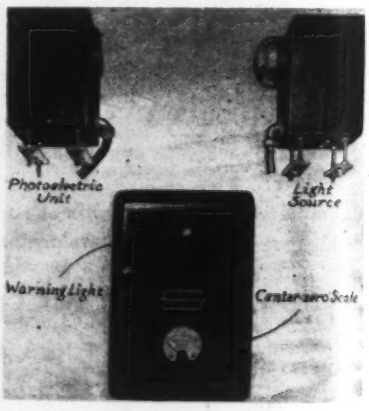


electrical equipment will be Class I Group D explosion-proof construction at a slight extra cost. Standard units of 125 and 150-lb. design can be supplied with ASME stamping, if desired. When these standard units are used in conjunction with refrigeration (especially in tropical climates) considerable increased capacity is obtained.—*Dehydraire Corp., 14-13 118th St., College Point, N. Y.*

Please mention number **803** when filling out card

Photoeletric Smoke Indicator

New "SGL-JS Smoke Indicator" is a photoelectric system comprising three units as shown in annotated photograph. "Color," rather than "density" of stack gases is measured. Instru-

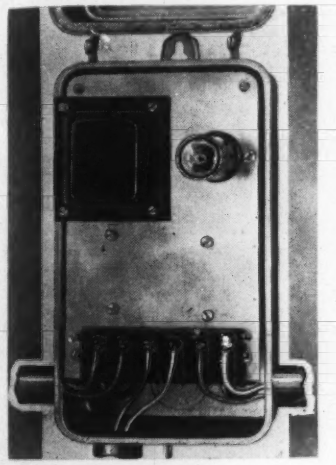


ment's purpose, therefore, is to facilitate optimal fuel and air adjustments for highest combustion efficiency. However, it can be used for detecting small amounts of dirt or smoke in rooms, ducts, etc., and for other purposes.—*Ess Instrument Co., 96 S. Washington Ave., Bergenfield, N. J.*

Please mention number 804 when filling out card

"Foamless" Liquid-level Control System for Milk, etc.

New "Model FMF Faratron Electronic Control" is not affected by liquid foam of any kind, operates only when liquid itself contacts antenna, hence is suitable for milk, food, and beverage tanks and containers or kettles where foam has heretofore been a handicap in measuring exact volume of liquid in



the containers. By use of a specially-designed antenna or electrode, said to operate on a new electronic circuit principle, foam does not activate control relays. This is said to make new system particularly valuable in regulating fullness in vats and tanks, or to measure and control exact intermediate levels in mixing and blending processes. New "Model FMF" is said to be "probably the most accurate and most completely dependable liquid level control ever designed and made for the dairy, food, brewing or bottling industries." It is absolutely sanitary for all food measuring and processing.—*Lumenite Electronic Co., 407 South Dearborn St., Chicago 5, Ill.*

Please mention number 805 when filling out card

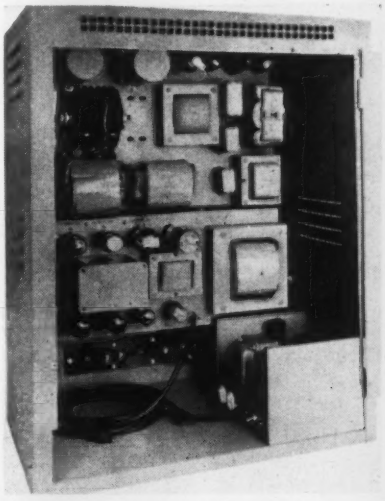
Aluminum-alloy Pressure-gage Case

New "Acaloy" gage case is made of a high-compression molded aluminum alloy. Surface of case is treated by a patented process to prevent corrosion, and it is claimed that the case will withstand 1500 hours salt spray test. Over this treated surface there is a black baked-on finish. Case is claimed to be weather-proof since it is provided with a synthetic rubber sealing gasket and a stainless steel snap ring. New case is designed to accommodate safety blowout disks, which are supplied when required.—*Helicoid Gage Div., American Chain & Cable Co., Bridgeport, Conn.*

Please mention number 806 when filling out card

Regulated D-c. Source for Instrument Testing

New "Model E-3006" voltage regulator provides a highly-stable precisely-regulated source of d-c. voltage and current especially applicable for testing of instruments. Unit measures approx. 36″ × 30″ × 18″ deep. Physically it is divided in half: upper half is a modified "Nobatron" with 95 to 125 volts a-c input voltage range; 6-volt d.c. output

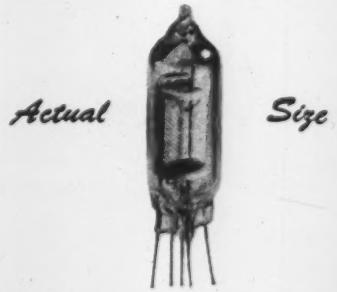


voltage; load range 7½ to 15 amps.; regulation accuracy 0.1%; ripple voltage RMS max. ½%; recovery time 0.2 sec. and ambient temperature range −50°C to +50°C. Lower half contains a regulated d-c. power supply with: input voltage range 90 to 135; output voltage 0 to 300 volts d.c. continuously adjustable; load capacity 100 ma.; regulation accuracy 0.1% input frequency range 50 to 60 cycles. The input voltage of this regulated d-c. power supply has been made extremely stable and accurate through the use of maker's "Model 150" which controls input line voltage. As a result, output is kept at its setting without variation.—*Sorensen & Co., Inc., Stamford, Conn.*

Please mention number 807 when filling out card

Subminiature Electrometer Tube

New "Type VX-41" subminiature electrometer tube incorporates a design change minimizing microphonics. In many applications this has not been

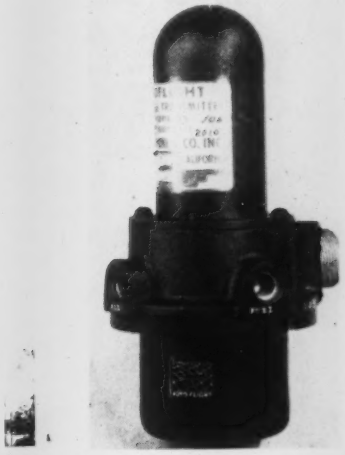


a critical factor but, for many other uses, new low-microphonic feature widens scope of successful application. Especially is this true in improving performance of many portable instruments and other uses where vibration has been a deterring factor in the past. In d-c. amplifiers, new tube will meet exacting demands. Other tube characteristics include: filament voltage, 1.25 volts (opt); filament current, 10 ma.; grid current, less than 10^{-15} amp.; grid resistance, greater than 10^{15} ohms. —*The Victoreen Instrument Co., 5806 Hough Ave., Cleveland 3, Ohio.*

Please mention number 808 when filling out card

Pressure Transmitter

New "Series 4600" pressure transmitter is a new model of device fully described in *Instruments*, April 1946, pages 234-235. New units are designed for use with various gases and liquids such as air, oxygen, water, oil, gasoline, alcohol, hydraulic fluid, anilin, etc. They combine controlled-action bellows or Bourdon tubes, and "Micro-



torque Potentiometers." New units can be supplied in resistances from 100 to 20,000 ohms; and ranges of 0 to 500 lbs./in.² with special ranges on application; accuracy 2%; approx. weight 1.3 lbs.; over-all length under 6″; maximum width 3″.—*Autoflight Instruments Div., G. M. Giannini & Co., Inc., 285 West Colorado St., Pasadena 1, Calif.*

Please mention number 809 when filling out card

Soft-radiation Counter

New "Libby Screen Wall Counter" is designed for measurement of (1) radioactive samples of low specific activity and (2) extremely soft radiations which are greatly attenuated by passage through even thin counter windows. It can count all types of particle radiation: alpha particles, beta particles, and conversion (Auger) electrons. Its use is indicated in the following circumstances: (a) any radiation from a sample of extremely low specific activity which is available in large quantities; (b) soft radiation from a sample which cannot be obtained as a suitable gas. "Libby Screen Wall Counter" is essentially a Geiger-Mueller Counter with a "wall" of wire screening mounted inside a cylindrical metal shell. Radiation enters counter volume through screen so there is no window at all to impede its passage. Absorption by screen is rendered negligible by use of a positive collecting voltage between screen and outer shell. Solid sample is mounted on one half of the surface of a cylinder which is

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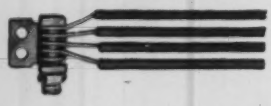


Vacuum-processed, gold-coated Bradley instrument rectifiers increase equipment efficiency. Especially designed for use where stability and permanence of calibration are important, "Coprox" rectifiers meet the most exacting requirements. Yet they cost no more than ordinary rectifiers — in most cases, less.

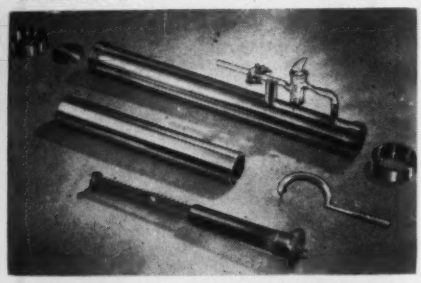
Temperature error is exceptionally low with Bradley rectifiers. Aging is practically nil. Pre-soldered leads. Rating of CX-2E series up to 4.5 volts A. C., 3 volts and 5 milliamperes D. C.

Illustrated literature, available on request, shows more models of copper oxide rectifiers, plus a line of selenium rectifiers and photocells. Write for "The Bradley Line."

BRADLEY LABORATORIES, INC.

82 Meadow St. New Haven 10, Conn.

free to slide back and forth inside shell, coaxial to screen. Sample cylinder is inserted through one end of shell; shell closed, evacuated, and filled with an appropriate counting gas. (Approx. 20 min. required for this operation.) By filling shell, sample cylinder can be caused to slide to a position in which

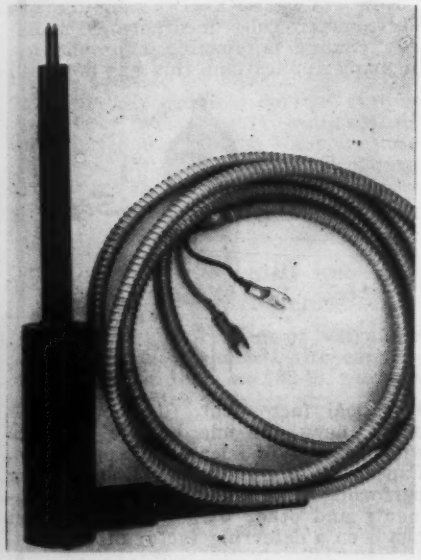


sample is not exposed to sensitive area of counter and background of instrument determined. Sample is then brought back to counting position and its activity measured. By alternating sample and background counts, activities of a small fraction of background can be measured accurately. By maintaining screen at a positive voltage with respect to wall, volume between screen and sample acts as a collecting region. All ions produced there are "dragged in" to the Geiger-counter volume producing a count. Thus, geometry of instrument is essentially 50% and may be even higher if there is appreciable backscattering. Absorption curves in aluminum or other absorbing materials can be conveniently run so as to provide evidence for identity of activity being counted. This has been done for example, with H^3 beta radiation of max. energy 10 kv., max. range 0.2 mg. Al/cm^2. — *Radiation Counter Laboratories, 1457 E. 57th St., Chicago 37, Ill.*

Please mention number 810 when filling out card

Spring-loaded Prod-type Thermocouple Assembly

New two-point thermocouple assembly is recommended especially for measuring temperature of non-ferrous alloy billets at time of forging or extruding. It is especially adaptable to work in conjunction with high-speed

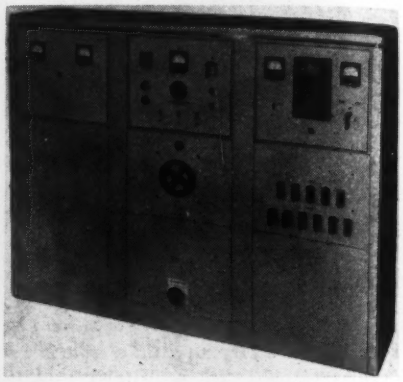


potentiometers though it may be used with millivolt type pyrometers. Renewable points can be supplied or made from standardized thermoelements. Each pointed thermoelement is spring-loaded so that irregular shaped billets or partly-formed forgings can be checked within heating oven without damage to thermocouple assembly. Entire assembly within the tubes can be withdrawn for inspection and tip replacement by removing two short screws. Made to order only of any base metal thermocouple wire, device can be supplied in lengths of 4" to 10 ft. —*The Industrial Instrument Service Co., 2785 Slauson Ave., Huntington Park, Calif.*

Please mention number 811 when filling out card

High-precision Source-unit for Spectrochemical Analysis

New source unit for spectrochemical analysis has been designed specifically for high quantitative precision and accuracy. It provides two basic spectrum sources—one of high voltage and frequency used for higher-percentage determinations; one of low voltage and frequency used for lower-percentage analyses. Both sources employ same principle as maker's previous "Multisource," completely separate charge and discharge cycles. This provides a high degree of reproducibility. High-voltage source utilizes 240 spark trains per second of short duration for excellent sampling; low-voltage source, 60 arc discharges per second of long duration for high sensitivity. A wide range of circuit constants can be furnished to provide optimal conditions for any type of sample to be analyzed. Adequate intensity is provided for all applications with a direct-reading instrument or with any type of spectrograph.—*Applied Research Laboratories, 7707 Michigan Ave., Detroit 10, Mich.*



Please mention number 812 when filling out card

Hard-faced Plug Gages

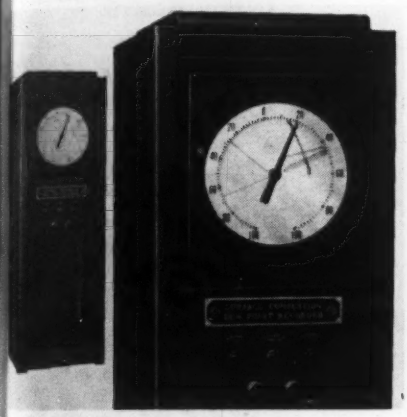
New "Ritoloy" hard facing is available on maker's line of gages. It is claimed that new gages "will outwear hardened steel gages by 30 times and chrome-plated gages by 4 to 6 times. Their cost approximates that of chrome-plated gages." Hard alloy is molecularly bonded to steel base or shank, will withstand shock and not peel; is not brittle, therefore does not chip or crack. Finished gages, after grinding and lap-

ping, have a "Ritoloy" thickness of .008" on a side (as much as 0.035" on a side is possible). Undersigned company is primarily concerned with manufacture of new gages, but can "Ritoloy" old steel or chrome-plated gages, or build up worn "Ritoloy" Gages to size.—*Rite-O Tool & Gage Co., 59 E. Eight Mile Road, Hazel Park, Mich.*

Please mention number 813 when filling out card

Furnace-atmosphere Humidity Recorder

New Dew-point Recorder permits obtaining close control of effects of water vapor in all types of furnaces utilizing gaseous atmospheres. It provides a virtually continuous record of humidity of the furnace atmosphere. It utilizes dew-point cup principle and its operation is independent of nature or composition of gases making up furnace atmosphere. Presence of hydrogen sulphide and sulphur dioxide have no effect upon record-

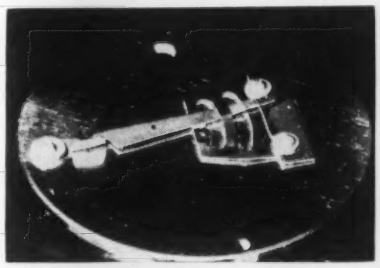


er's accuracy. Analysis of furnace gas is unnecessary. Principal units of recorder are a dew-point cup with mirrored surface which can be refrigerated at varying temperatures, a thermocouple connected to a recording potentiometer, and the refrigerating unit with its associated system. In operation a stream of furnace gas is directed against mirrored surface of dew-point cup, and a refrigerant is circulated around cup. As temperature of refrigerant drops (lowering temperature of mirror) a film forms on surface when dew-point temperature of the gas is reached. As soon as film forms upon mirror, it intercepts a light beam which has been directed upon a photocell. When this takes place, cell alters current, which in turn shuts off flow of refrigerant around mirror, at the same time making an instantaneous point record of that temperature on recorder chart. Standard dew-point temperature range, −40°F. to room temperature; special recorders can be provided to record dew-points to −80°F. Approx. dimensions, 2×2×6 ft.—*Surface Combustion Corp., Toledo 1, Ohio.*

Please mention number 814 when filling out card

Scratch-recording Strain Gage

New model is available of the de-Forest scratch recording strain gage, which became unavailable during the war. Announcement states that it "is believed to be the smallest, lightest and lowest cost recording strain gage ever devised." It is self-contained, weighs less than two grams, and records deformations of 0.0001" to 0.050" by a scratch pattern on a small polished chrome-plated target. Illustration shows use in measuring strains in a small disk. Scratch record is made by abra-

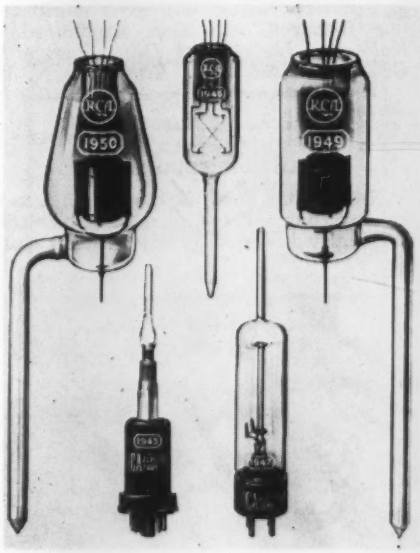


sive on end of a 2" arm which is held on the target. Gage may be fastened to member under test by screws, solder, spot welds, clamps, etc. Attachment is made with scratch arm parallel to direction of strain. Deformation of member causes longitudinal movements of scratch arm and target relative to each other while arm gradually sweeps across target. Gage is mounted with scratch arm centered on target. When ready for test, arm is pushed to one side or other of target, thus marking zero lines across which scratch records are made, and setting up a restoring force in a fulcrum spring in arm. Rate of arm movement can be adjusted to make closely-packed or spread-out records. Two records can be made on each target and, by using removable half-targets, several records may be made before removing the gage. Record may be measured under a filar eyepiece microscope of about 100 to 250× or photographs of up to 1,500× may be made.—*Baldwin Locomotive Works, Philadelphia 42, Penna.*

Please mention number 815 when filling out card

Vacuum-gage Tubes

New line of five vacuum-gage tubes is announced for measuring high vacuum in certain kinds of industrial machinery, as well as "workaday" vacuum used in many manufacturing processes. "RCA-1945" (bottom, left) is an ioniza-



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tion gage tube sensitive only to hydrogen: palladium plate, when hot, is porous to hydrogen but a vacuum-tight barrier to all other gases and vapors. In operation, this tube is connected into vacuum system to be checked for leaks and a tiny jet of hydrogen is played over outside areas of system. Tube is sensitive enough to detect an increase in hydrogen pressure of less than 0.0000001 mm. of mercury. Two other new ultrasensitive ionization-type tubes are "RCA-1949," a hard-glass tube, and "RCA-1950," soft-glass. For use in equipment where parts might burn up if high voltages are applied before required vacuum is reached, two "watchdog" vacuum-gage tubes were developed: "RCA-1946" is a thermocouple type; "RCA-1947" is a Pirani type.—*RCA Tube Dep't, RCA Victor Div., Radio Corp. of America, Camden, N. J.*

Please mention number 816 when filling out card

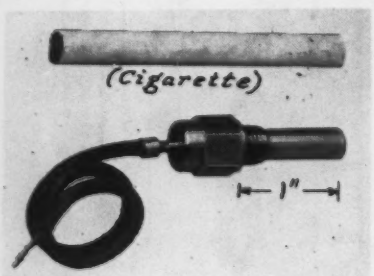
Aircraft Engine Tachometer and Hour Meter

New "Tacholog" is a combination tachometer and engine-hour recorder which obviates need for keeping an engine log by totalizing engine hours based on the average cruising speed of 2000 rpm. It is said to give unusually accurate indication of engine wear, as engine hours are counted at a slower rate when engine is idling and more rapidly when engine is operated at a speed higher than stated cruising speed. Since a simple conversion gives equivalent hours for various other cruising rpm., unit is suitable for all types of aircraft. "Tacholog" is made either with counter-clockwise or clockwise tachometer drives. It is said to be lighter in weight than tachometers previously available. (Owners of personal aircraft will appreciate elimination of a separate engine time recording instrument and the lighter weight of the new combination instrument.) Another advantage is that instrument does not have any adverse affect on compass even when the two are installed side by side. "Tachalog" fits AN standard 3⅛" mounting hole; connection is standard SAE ⅞—18 T/I screw type. New aircraft tachometers, without the engine hour recorder, lighter in weight and incorporating improved engineering features, are also announced.—*Kollsman Instrument Div., Square D Co., 80-08 45th Ave., Elmhurst, N. Y.*

Please mention number 817 when filling out card

Small Thermal Switch

New "Plug-Stat" is said to be a new type of thermal control and limit switch, originally designed for high-temperature



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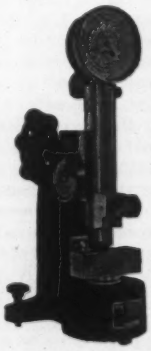

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alarm in railway journal boxes, thrust and roller type bearings, etc., also to indicate high or low temperatures in fluids under pressure, crank-cases, oil temperatures, exhaust stack temperatures, etc. It can be installed by merely drilling and tapping either a ⅛-27 N.P.T. or by drilling and tapping an N.F.-2, ⅜-24 thread. Thermal characteristics: control range, 60°F. to 600°F.; differential ±30°F.; electrical characteristics a.c. or d.c. 28 volts 2 amperes, one side normally grounded to case; can be had in normally open or closed circuit. Weight 0.67 oz.; materials of case, cold rolled steel, brass or stainless steel, depending on application; hermetically sealed against pressure, moisture and dirt; designed to operate under conditions of severe vibration, dirt and abuse.—*Control Products, Inc., 306 Sussex St., Harrison, N. J.*

Please mention number 818 when filling out card

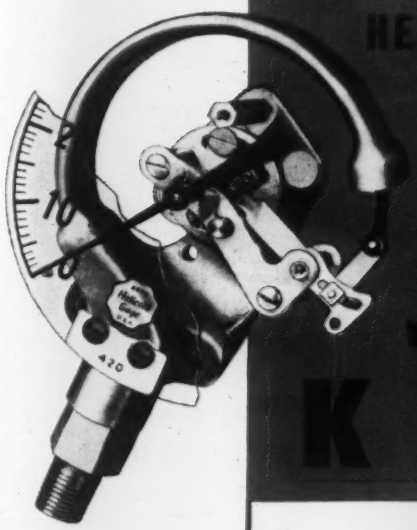
Appliance Temperature Tester

New "Model 50-50," for quick, accurate check of operating temperatures of refrigerating equipment, tests cold

zones in the range of −50°F to +50°F, and gives continuous reading outside equipment being checked. Temperature element, small enough to be inserted in hard-to-reach places, has a 14-foot lead of polyethylene, which stays flexible even at −50°F. and is so thin it does not interfere with weatherstrip.—*J-B-T Instruments, Inc., Chapel St., New Haven 8, Conn.*

Please mention number 819 when filling out card

New "Model ACA-100 GE" has been specifically developed to accommodate the General Electric Variable-reluctance Magnetic Pick-up without use of any additional pre-amplification or



HELICOID GAGE

FIRST

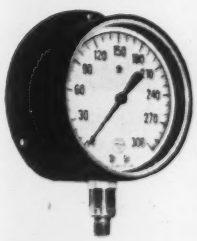
with Bourdon Tube of

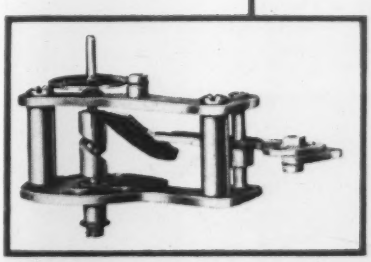
K MONEL

With superior spring characteristics and high resistance to corrosion, K Monel is unequalled for certain difficult pressure gage applications. In actual service under the worst corrosive conditions, such as Hydrogen Sulphide gas or oil, Helicoid Pressure Gages with K Monel Bourdon Tubes have remained accurate ten times longer than gages with stainless steel tubes.

K Monel Bourdon tubes are made of Korex tubing, with extra-smooth inside wall, for all pressures from 30 p.s.i. to 10,000 p.s.i.

- **These tubes are fused** to forged Monel sockets and tips—no solder, no welding rod—providing an integral Monel system. Heat-treated to obtain maximum spring properties in tube.
- **K Monel Gages cost no more** than stainless steel tube gages. Yet they are infinitely superior for prolonged accuracy and low hysteresis effect.
- **Try Helicoid Gages now** with K Monel tubes. Send for your copy of the new Helicoid Gage catalog.





The Helicoid Movement is one of many exclusive features of the Helicoid Pressure Gage.

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POWERFUL NEWS!

SORENSEN SYSTEM NOW APPLIED TO DC VOLTAGE REGULATION

The Sorensen system of AC electronic voltage regulation provides quick, accurate response to even the smallest voltage change with a minimum wave distortion and a regulation accuracy of ½ of 1%.

Arrange now to receive your personal copy of the Sorensen electronics journal "Currently", published bi-monthly.

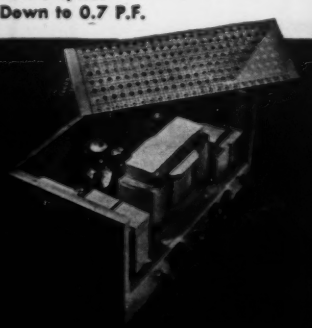
This same electronic regulation system has been incorporated into the Nobatron, providing a source of regulated DC voltage at currents and stabilities that, in the past, was available only with batteries.

This new source of stabilized DC voltage is obtainable in six standard models operating on a 95-125 AC source of 50 to 60 cycles.

Among the more important uses for Nobatrons are DC ammeter calibration in experimental and quality control laboratories, testing of components in the automotive and aircraft industries in battery-operated relays and in other applications where it is desirable to replace a battery to guarantee continuous regulated power supply.

GENERAL AC REGULATOR SPECIFICATIONS

Input Voltage Range	(—1 model)	95-125
	(—2 model)	190-250
Output Voltage Range	(—1 model)	110-120
	(—2 model)	220-240
Load Range		25-30,000 V. A.
Regulation Accuracy		½ of 1%
Harmonic Distortion		5% Max. (2% in "S" Models)
Input Frequency Range		50-70 cycles
Inductive Power Factor Range		Down to 0.7 P.F.



For standard voltage regulation, Sorensen Model 500 is a proven leader in its field—compact, accurate and dependable. This model typifies the Sorensen line of AC and Nobatron all-purpose voltage regulators. Let a Sorensen engineer help you with your next voltage regulation problem.

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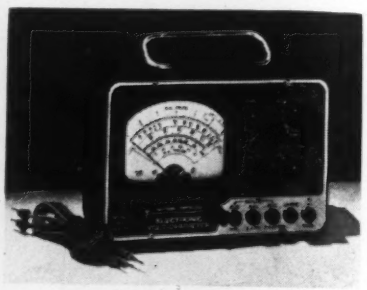
equalized circuits. It is equipped with a built-in specially-designed low noise and low-hum pre-amplifier and tuned pre-equalizer to fully compensate for characteristics of pick-up; also a variable high-frequency equalizer for compensation of pre-emphasized recorded and radio programs, as well as a low-frequency equalizer for full compensation of constant-amplitude recordings. Unusual circuit design features include a non-frequency-discriminating scratch suppressor which effectively reduces scratch by 10 db, a non-overloading push-pull expander which provides a continuously-adjustable control up to 10 db expansion, introducing less than 1.5% distortion under full expansion. Unit is guaranteed for five years. Power consumption 150 watts. Overall dimensions 17½" × 10" × 10". Net weight 40 lbs. — *Amplifier Corp. of America, 398-17 Broadway, N. Y. 13, N. Y.*

Please mention number 820 when filling out card

Portable Volt-ohmmeter

New "Model 214 Electronic Volt-Ohmmeter" is self-contained, battery operated, obviates need for plugging in

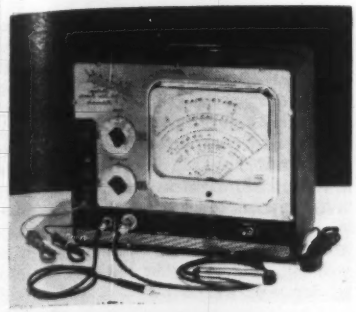


to an a-c. line, is said to be not only ideal for rural areas where no a-c. is available, but most useful for checking radio in the field. For resistance and voltage tests, sets need not be removed from autos, ships, or aircraft. Built for self-checking of battery condition at any time, it is usable for 1350 4-minute operations; requires no warm-up period. Indicator is electronically protected against burn-outs. Ranges: A-c. volts: 0-3, 12, 30, 120, 300, 1200; d-c. volts: 0-3, 12, 30, 120, 300, 1200; resistance: 1 ohm to 1000 megohms in 6 ranges. Input Impedance: a-c.: 10 mmf—15 megohms; d-c.: 15 megohms. Dimensions: 8¼"×6"×4¼". Weight: 5¼ lbs. *The Hickok Electrical Instrument Co., 10519 Superior Ave., Cleveland, 8, Ohio.*

Please mention number 821 when filling out card

Volt-ohm-capacitance-milliammeter

New 'Model 209 Electronic Volt-ohm-capacity-milliammeter" has a low-capacitance, high-frequency-probe, is designed for use in measuring any voltage, capacitance or resistance that may be encountered in any radio receiver, without any danger of damaging indicator from over-load. Extremely light loading of d-c. circuits under test results from isolating resistor in probe. Its 9" indicator with long scale affords easier and more accurate reading. "Model 209" measures d-c. voltages



across AVC discriminator and limit circuits (d-c. circuit rejects all a-c. voltages). Polarity reversing switch permits use on d.c. without changing lead connections. Set measures resistance from 0.1 ohm to 10,000 megohms; any capacitance such as electrolytics, mica, paper, variable air capacitors, trimmer capacitors, etc.; a-f., i-f. and r-f. voltage from 30 cycles to 300 megacycles. Makes any d-c. current measurement required, including plate current, cathode current, or power supply drain. Power supply required is 105-125 volts, 60-70 cycles a.c.; power consumption is 20 watts at 115 volts. — *The Hickok Electrical Instrument Co., 10519 Dupont Ave., Cleveland 8, Ohio.*

Please mention number 822 when filling out card

Xenon-filled Rectifier Tube

New "EL 6B" xenon-filled half-wave rectifier tube is for uses that demand the reliability of a rare-gas-filled tube. Rectifiers using this tube may be built for d-c. output up to 440 volts 12.8 amp. single-phase or 650 volts 19 amp. polyphase. Applications include powering d-c. motors, magnetic devices and other loads requiring sizable d-c. power.—*Electrons, Inc., 127 Sussex Ave., Newark 4, N. J.*

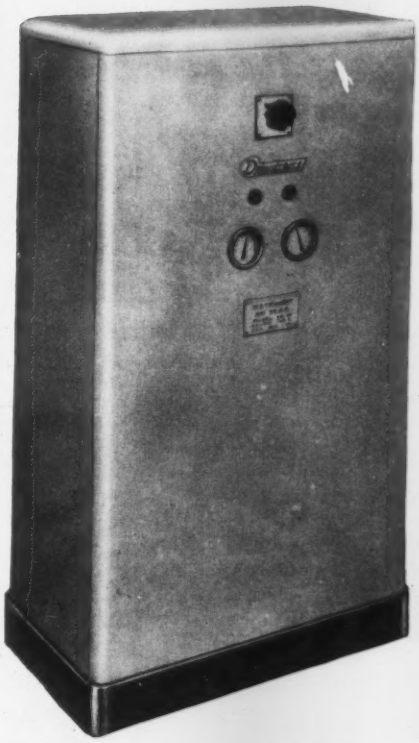
Please mention number 823 when filling out card

Capacitor and Resistor Tester

New "Model TO-3 De Luxe Telohmike" has, in addition to all features of previous "Telohmike" models, a "Speedy Check" that enables operator to locate open, intermittent, or shorted

Announcing

A LINE OF INSTRUMENT AIR DRYERS



NOW—for the first time—standard off the shelf *Silica Gel DEHYDRAIRE units which insure clean and dry air—free of oil and water vapor.

DEHYDRAIRES with capacities of 12½ to 250 SCFM at 100 PSIG and 70°F will dry the air for 25 to 500 air operated instruments. The air leaving DEHYDRAIRES will have a final dew point as low as —50°F assuring absolute dryness regardless of coldest temperatures to which lines may be exposed.

Models for either single or polyphase electric reactivation or steam reactivation where steam pressures of 100 lbs. or over are available.

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DEHYDRAIRE Units will be exhibited at the Second Annual Instrument Conference and Exhibit, Booth No. 23, Stevens Hotel, Chicago.

Write for full description, prices, etc., to Sales Engineering Dept.

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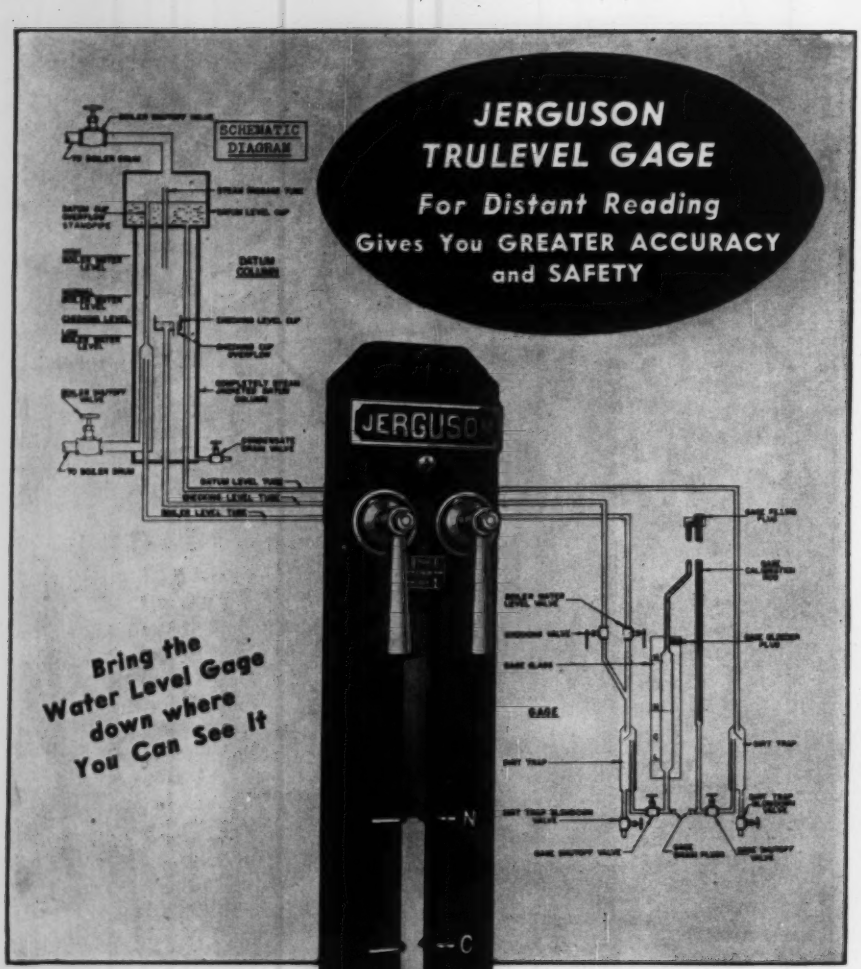

Jerguson Trulevel Gage may be either wall or panel mounted.

The Jerguson Trulevel Gage gives you greater accuracy and safety because it is precision engineered and built with these three important features:

1. Built-in checking feature for quick, easy checking of accuracy and operation. **2.** Easy-to-read water level indication. Water level appears in natural position, contrasted with brilliant blue of manometric fluid above. Back-illuminated. **3.** Positive reading through new datum column, which is fully steam jacketed and duplicates the temperature and specific gravity conditions which exist in the boiler drum.

Stainless steel construction for long, dependable service. Black crackle finish aluminum cover.

Three standard sizes: #1, for pressures up to 600 lbs. #2, for pressures up to 900 lbs. #3, for pressures over 900 lbs.

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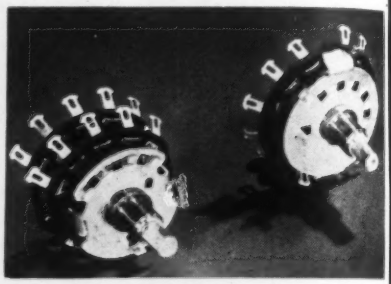
capacitors without removing them from circuit. It is a bridge-type capacitance and resistance analyzer with built-in d-c. volt-milliammeter. Direct-reading calibrated dial is color coded to correspond with selector switch. Capacitance ranges are from 0.00001 to 2,000 mfd. in 4 steps. Resistance ranges are 2 ohms to 25 megohms in 3 steps. D-c. measurement range is 0-15/150/750 volts; 0/1.5/15/75 ma. Direct reading insulation resistance range is 0-250 megohms. Electrolytic leakage is measured in ma. at rated d-c. voltage. Capacitance and power factor of electrolytic capacitors are measured with rating polarizing voltage applied. Power factor measurement range 0-50% at 60 cycles. New instrument is 13¼" × 10⅛" × 5" deep; weighs 15 lbs.—*Sprague Products Co., North Adams, Mass.*

Please mention number **824** when filling out card

Circuit-selector Switches

New "RSA-50 and RSA-60" single- and double-section circuit-selector switches are said to be useful when



space is a factor, dependability essential, and low cost a prerequisite. They are designed for band and tone control switching in radio receivers and other electronic applications where medium- and low-torque indexing action is desired. "RSA-50" accommodates up to twelve terminals on either side of the section and provides from 2 to 6 positions. "RSA-60" accommodates up to ten terminals on either side of the section and provides from 2 to 5 positions. —*P. R. Mallory & Co., Inc., Indianapolis, Indiana.*

Please mention number **825** when filling out card

Midget Electrical Instruments

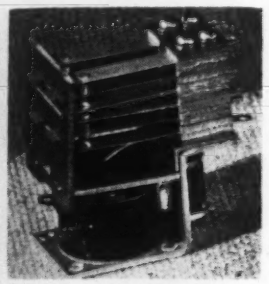
New 1" diameter electrical indicating instrument is believed to be "the smallest high-grade d'Arsonval type instrument commercially available." Barre

iameter is 1" and depth behind front f mounting is 1" including terminal uds. Maximum overall dimensions, inuding studs and mounting flange, 16" × 1 3/16". Movement is mounted n polished pivots in vee jewels. Owing small mass and low inertia it will and rough usage better than larger ovements (test result: free drop in cess of 24" on a wood block without mage to movement or case). Voltters, milliammeters, ammeters, milloltmeters and micrommeters can be pplied. Maximum voltage range, selfontained is 500 volts. Rectifier and hermocouple types are available. Alni V magnets with machined soft iron oles provide high flux, low response me and good damping. Cases are of ear plastic. Hermetic sealing is possile.—*Assembly Products Inc., Chagrin Falls, Ohio.*

Please mention number 826 when filling out card

Small Multipole Relays

New series of small-size multipole relays feature a versatile arrangement of contact systems (maximum 4-pole

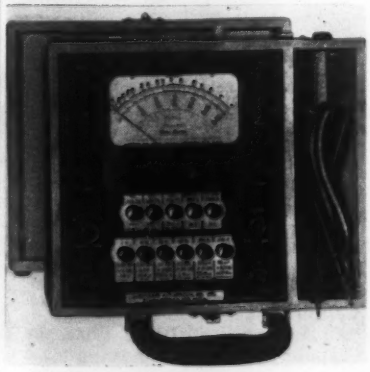


double-throw) capable of handling almost any control circuit where currents do not exceed 12½ amps. at 115 volts a.c. non-inductive. Movable phosphor-bronze pole pieces give a positive self-wiping action and handle high as well as low currents. Where mounting space is limited, or inaccessible, new relays have a special value because of their small size (approx. 1" × 1⅞" and 1½" high). Coils can be furnished for shunt, series, a-c. and d-c. operation. D-c. coils consume approx. 3 watts; a-c. coils approx. 6 va.—*Leach Relay Co., 5915 Avalon Blvd., Los Angeles 3, Calif.*

Please mention number 827 when filling out card

Fifty-four-range Test Set

New "Series 858 Precision Multi-Master" covers 54 a-c. and d-c. ranges, is said to make laboratory and field



Stop in at BOOTH No. 90 when you're in Chicago at the Instrument Show. See some of the unusual dry battery problems Burgess engineers have helped solve —see how they might help you.

Meantime, if you have a special problem of dry battery engineering or design, send for free handy Check Sheet—the easy way to take advantage of the complete Burgess engineering facility.

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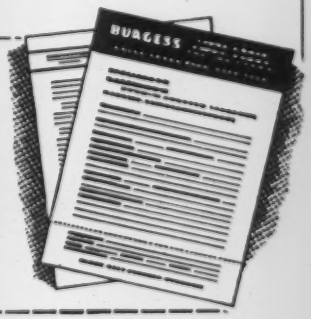

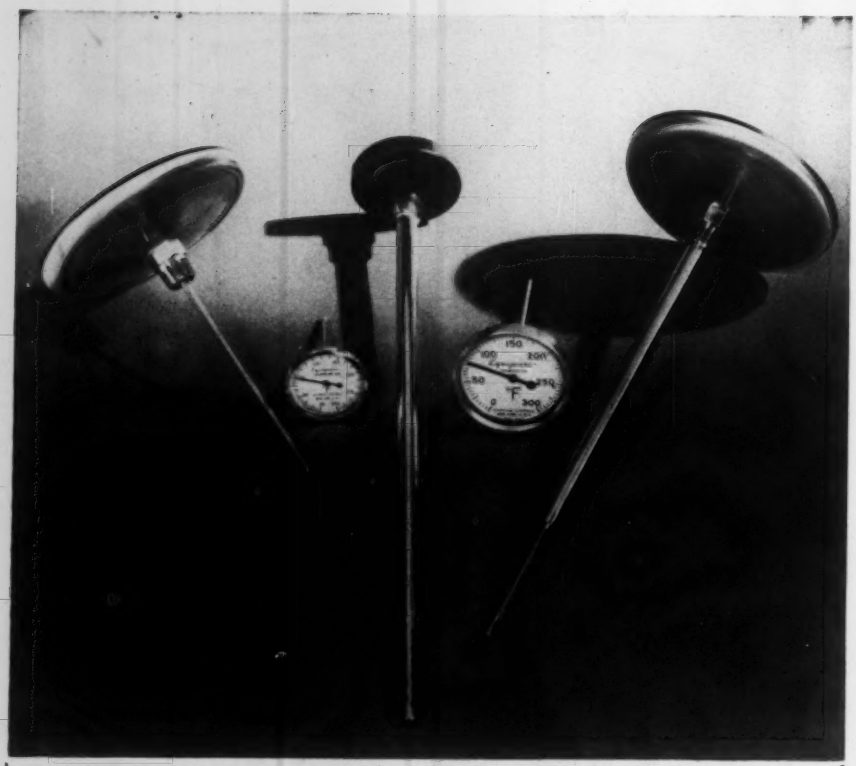

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for every industrial and laboratory use

Widely used in power plants, chemical plants, oil refineries, paper and textile mills, etc. Also on refrigeration, air conditioning and electrical equipment.

Many standard ranges are available between the limits of minus 90°F. and 1000°F.

- Easy to Read Dial
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- Only One Moving Part
- High Over-range Protection
- Individually and Permanently Calibrated
- No Pinions, Gears or Linkages
- Calibration Unaffected by Vibration
- Durable Stainless Case, Connection Nut & Stem
- Available with Tempered, Non-breakable Crystals
- Available in 2, 3 & 6 inch Dial Sizes
- Heavy Duty Sockets are Standard
- Low Cost—No Maintenance

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testing "a streamlined push-button operation." It is a 20,000-ohm-per-volt wide-range test set for reliable high-speed measurements in modern electronic circuits. It features automatic push button range and function selection system. One row of five buttons selects all functions such as volts, ohms, mils, decibels, amperes, and microamperes. The other row of six buttons selects all ranges: 54 ranges, to 6,000 volts, 600 megohms, 12 amperes 70 and 60 microamperes, 20,000 and 1,000 ohms per volt d.c. 1,000 ohms per volt a.c. "Series 858 is available in two models: "Model 858-P" (portable) in hardwood case with tool compartment; "Model 858-L" for laboratory use.—*Precision Apparatus Co., Inc., 92-27 Horace Harding Blvd., Elmhurst, L. I., N. Y.*

Please mention number 828 when filling out card

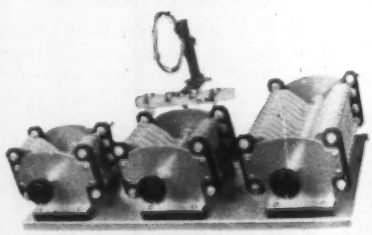
Viscometer Extension Spindle

New Extension Spindle greatly extends usefulness of "Synchro-Lectric Viscometer." Point of process reading can be taken where it was formerly impossible owing to heat, boiling, foaming, fumes, etc. New Extension Spindle is useful also where surface turbulence or undulation of liquid level made accurate readings impossible. Spindles can be supplied in any length needed, enabling operator to be comfortably far above liquid being tested. Readings can even be made from floor above by passing spindle through a small hole in ceiling. (A platform can be utilized in same manner.) New Extension Spindle is interchangeable with standard spindles; can be used on all maker's viscometers except "Model MV."—*Brookfield Engineering Labs., Stoughton, Mass.*

Please mention number 829 when filling out card

Butterfly Type Variable Capacitors

New "Type JCX" variable capacitors incorporate construction features of maker's large "Type CX" for heavy-duty applications: opposed stator sections to provide short r-f. paths; butterfly rotor construction that permits grounding rotor at center of the r-f. voltage point with respect to stators; coils can be mounted directly on capacitors for maximum efficiency. New units have 25% of frontal area of "CX." Airgap is 0.125". Three standard types: "JCX100E" having a mount-



g length of 5½" and a capacity of 0mmfd. per section; "JCX50E," 3-" and a capacity of 50mmfd. per sec-n; and "JCX25E," 2-¾" and 25mmfd. *Barker & Williamson, Inc., 237 Fair-ld Avenue, Upper Darby, Pa.*

Please mention number 830 when filling out card

Resonant Relays

New Resonant Relays for remote-ntrol purposes are available up to 00 cps. Previously they were made ly in the range of 153 to 442 cps. elays use vibrating-reed mechanism sponding to one narrow band and jecting others. For illustrated tech-al description see *Instruments*, Jan. 947, page 72.—*Stevens-Arnold Inc., 22 lkine St., So. Boston 27, Mass.*

Please mention number 831 when filling out card

Rotameter Kit

New flexible rotameter kit, for meas-ring low flow rates in laboratory and ilot plant research, consists of one fully-shielded rotameter case as illustrated, four metering tubes readily interchanged in the case, and 16 spherical floats, 4 each in Pyrex, aluminum, stainless steel and Monel. With this combination, 16 liquid flow ranges are obtained: 0.2 cc./min. to 200 cc./min. of liquid flow. Sixteen ranges in gases are also obtained: 10 to 7000 cc./min. With addition of two larger tubes and four floats, top range can be extended to 0.20 gpm. of liquid and 0.60 cfm. of gas. A base plate for a stand and hose connections may be supplied. "No waiting for flow meters is necessary when an inspiration strikes the researcher who has this kit as his constant disposal." Delivery from stock.—*Brooks Rotameter Co., Box No. B-5747, Lansdale, Pa.*

Please mention number 832 when filling out card

Insulation Tester

New "Model 184A" insulation tester (shown with front-cover removed) measures insulation resistance of power cables, transformers, capacitors, switches and wiring assemblies at any desired d-c. voltage up to 10 kv. Breakdown voltages also can be accurately determined with a minimum of damage

TEST

. . . for volts, amperes, or watts with this one small, compact instrument

Here is the first appliance tester ever made that gives you volt, ampere, and wattage readings all from one small, compact instrument.

Model 390 slips easily into a large pocket, weighs only a pound and a half, is designed for hard, continuous service.

The range of uses for this volt-amp-wattmeter is almost unlimited in checking line voltage, current drain and power consumption, the three simple tests which will diagnose most cases of electrical trouble. In fact, practically any household electrical appliance that has a motor or a heating element, can be tested by the 390, as well as certain industrial installations.

You merely plug Model 390 and appliance to be tested into the Break-In plug furnished—voltage will read. To read watts or amperes, simply press one of the two buttons at bottom of the panel.

Aside from its unique features, Model 390 has no equal among appliance testers in quality alone. The famous Simpson quality makes investment in the Model 390 an investment that will return a rich yield in satisfactory service through the years.

USE MODEL 390 FOR TESTING

Refrigerators	Motors
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Washing Machines	Radio Sets
Irons	Lamps
Toasters	Vacuum Cleaners

and all similar appliances

RANGES

A.C. Current, 60 Cycles

Volts: 0-150, 0-300.

Amperes: 0-3, 0-15.

Watts: 0-300, 0-600, 0-1500, 0-3000.

Size: 3" x 5⅞" x 2½". Weight 1½ lbs.

Shipping weight 3 lbs.

Price, with Break-In plug and leads $39.50

Leatherette carrying case, with leads compartment $4.00

Genuine leather carrying case, with leads compartment $8.00

Simpson Model 390 Volt-Amp-Wattmeter

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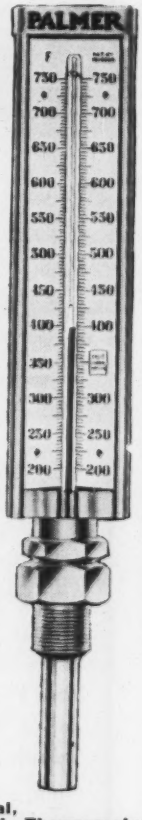

● You don't have to squint or strain to get positive readings with the new Palmer Thermometer. The new extruded case permits a larger reading scale, and Palmer's "Red-Reading Mercury" feature stands out vividly . . . like a traffic light on a rainy night.

And both Beauty and Accuracy are combined in this new thermometer. Beautiful chrome finish is standard on 7, 9, and 12 inch case sizes, durable nickel on the 4 and 6 inch case sizes. For full information write for new Bulletin 46-2 and 46-3.

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Canadian Plant: King & George Sts., Toronto 2

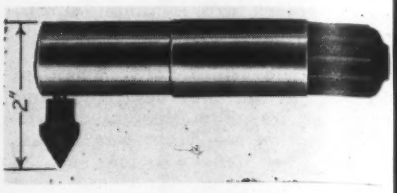
due to burning. Two separate circuits measure high resistance at desired voltage. Full manual control is provided for selecting any output voltage up to maximum. Over-all accuracy is within 5%. Resistances ranging from 0.1 to 50,000 megohms may be read directly on a megohmmeter scale at open circuit voltages of 0.5, 1, 5, and 10 kv. or may be simply calculated in ranges from 0.3 to 20,000 megohms from the readings of a voltmeter and microammeter connected to read resistance at any desired test voltage from 100 volts to 10 kv. Either methods is selected on one switch. Leakage current ranges are 30, 150, 300 and 1500 microamperes, readable at any voltage. For polarization checks, a polarity-reversing switch allows either positive or negative side of the voltage supply to be grounded. New tester operates from a 115-volt 60-cycle line and consumes a maximum of 65 watts. Speed in taking measurements is possible because of high current ranges, permitting rapid charging of capacitors and cables containing capacitance and rapid discharge of capacitance after test. Safety features include a relay for automatic and rapid removal of dangerous residual capacitance charges. Relay connects output terminals through a 50,000-ohm 100-watt resistor when power is turned off. It may also be operated during test by depressing a push button switch. Provisions are made for remote control of the line switch by unskilled personnel, also for protecting microammeter and for preventing over-

voltage on higher ranges. Brass handles on the 65-lb. unit permit easy handling in the field.—*Radio Frequency Laboratories, Inc., Boonton, N. J.*

Please mention number 833 when filling out card

Tachometer Angle Adapter

New "Type 45" angle adapter for use with maker's hand tachometers permits measurement of speed in cramped

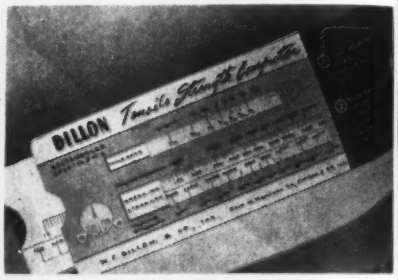


quarters where clearance at end of rotating shaft is as little as 2", is usable with "Type 61" disk for measuring linear speeds where clearance to sides of the moving member is limited. It slips readily over standard hand type head.—*Metron Instrument Co., 432 Lincoln St., Denver 9, Colo.*

Please mention number 834 when filling out card

Materials-test-data Computer

New hand-size Computer has all materials-testing data at fingertip view. User can ascertain lbs./in.^{2} or how big

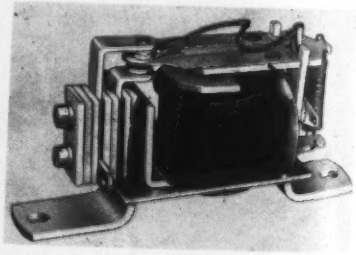


to make a specimen, or what load he will need. Knowing any two factors, the third factor is a ready answer. Computer covers rectangular specimens from $\frac{1}{32}$" to $\frac{1}{4}$" thick by $\frac{1}{2}$" to $1\frac{1}{2}$" wide, from 0 to 150,000 lbs./in.^{2}; reverse side covers rounds from $\frac{1}{16}$" to 1" diameter, up to 100,000 lbs./in.^{2}. Computer is not offered for sale, may be had without cost by engineers submitting their full name, company, and position. (Also high-school and college professors.)—*W. C. Dillon & Co., Inc., 5410 W. Harrison St., Chicago 44, Ill.*

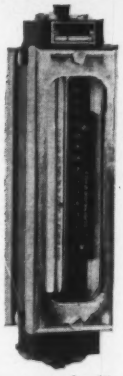
Please mention number 835 when filling out card

Flash-bulb-firing Relay

New "FR Series" relay for firing speed flash lamps is designed to discharge a high-capacitance capacitor



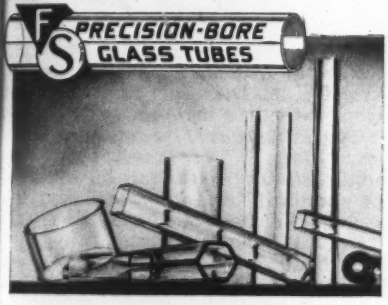
The Full-View ROTAMETER



gives lowest final cost

With labor and spare parts rising steadily in price, the final cost of an instrument becomes more and more the criterion for purchasers — The Full-View rotameter goes together with dowel pins that enable it to be assembled quickly and precisely, thus reducing maintenance time and breakage—The dowel pins, cap screws, gland bolts and window frames of the "Full-View" are made always of stainless steel to give it high corrosion resistance—Hence, less maintenance hours and fewer replacement parts make the Full-View rotameter lowest in final cost. For further details, write for Bulletin #20, Brooks Rotameter Co., Box A-5847, Lansdale, Pa.

BROOKS ROTAMETER CO.
LANSDALE, PA.



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F. S. Precision-Bore Glass Tubes are made to exact inside dimensions for application where interchangeability and precise bore are required.

Inside diameter: 0.216 mm (0.0085") to 100 mm (4") kept accurate within .01 to .001 mm (±.0004" to .00004").

For: Manometers, Viscosimeters, Flowmeters, Barometers, Gauges, Pumps and many other scientific, technical and industrial purposes.

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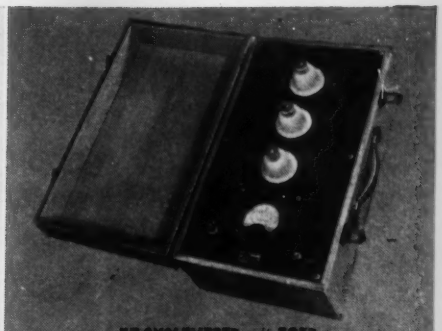
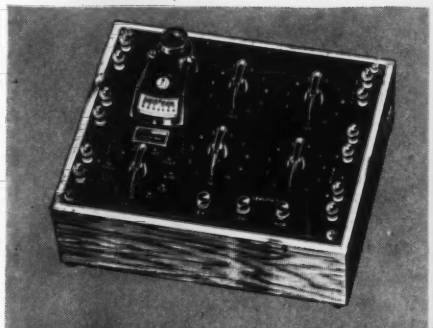
1,000 to 500,000 micro-ohms
(Other ranges from 200 micro-ohms to 100 ohms)



KILOVOLTMETER # 785P
AC-DC 5-10-20 KV
(Other ranges from 1.5 to 200 KV)

Shallcross



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0.0001 ohm to 11.11 megohms
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(Other designs, 1 to 7 dials, from 0.1 to 11,111,110 ohms)

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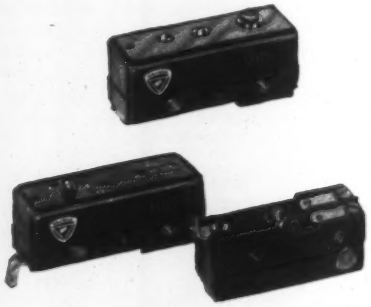
bank into the bulbs. A new contact material is employed which will withstand 1,000 amperes of impulse current. New relays are insulated for 3,000 volts breakdown, are equally suitable for use in studio or with portable equipment and utilize an overpowered actuating coil for fast, positive action. High silicon content steel is used in core, frame and full-floating, locked-on armature to reduce residual magnetism and assure uniform repetitive action. "FR" relay is available in all contact combinations up to d-p. d-t. for both a-c. and d-c operation. Proper circuit arrangement will allow use of up to three flash lamps from a single power supply.—*Potter & Brumfield Sales Co., Princeton, Ind.*

Please mention number 836 when filling out card

"Maintained-contact" Switches

New "Style C, O and U" "maintained-contact" switches are designed for services requiring compactness and accuracy of a precision, snap-action switch combined with a latch-out or latch-in feature whereby circuit established by momentary force application is maintained until restoring force is provided.

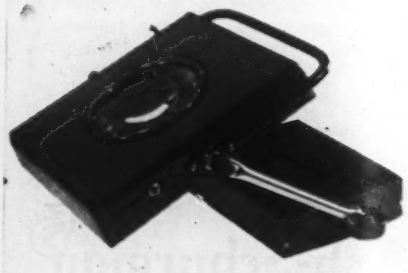


For use where initiating and restoring force are applied in the same direction, "Style O" has both operative and reset buttons extending through switch cover. For operating forces in opposite directions, "Style U" has reset button extending through base, can be equipped with standard "Adaptaplates" carrying various actuating members. Ratings, 15 amp. 125 volts, 5 amp. 250 volts, and ½ hp. 115-460 volts; all ratings are 60 cycle a-c. Style "O" is for s-p.s-t. service, style "U" is s-p.d-t.—*Unimax Switch Corp., 460 W. 34th St., New York 1, N. Y.*

Please mention number 837 when filling out card

Fluorescent Indirect-"daylight" Magnifiers

New portable fluorescent-lighted magnifiers with 5" dia. double convex lenses are announced. "No. PV2" is a single-lens model for continuous use.



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Visit us at the Second Instrument Conference and Exhibit at the Stevens Hotel, September 8-12, 1947 — and at any time you may consult us on any phase of radiation measurement including Geiger-Mueller Scalers, Geiger-Mueller Counters, subminiature electrometer tubes, high megohm resistors and other instruments associated with the measuring and protection problems of nuclear physics.

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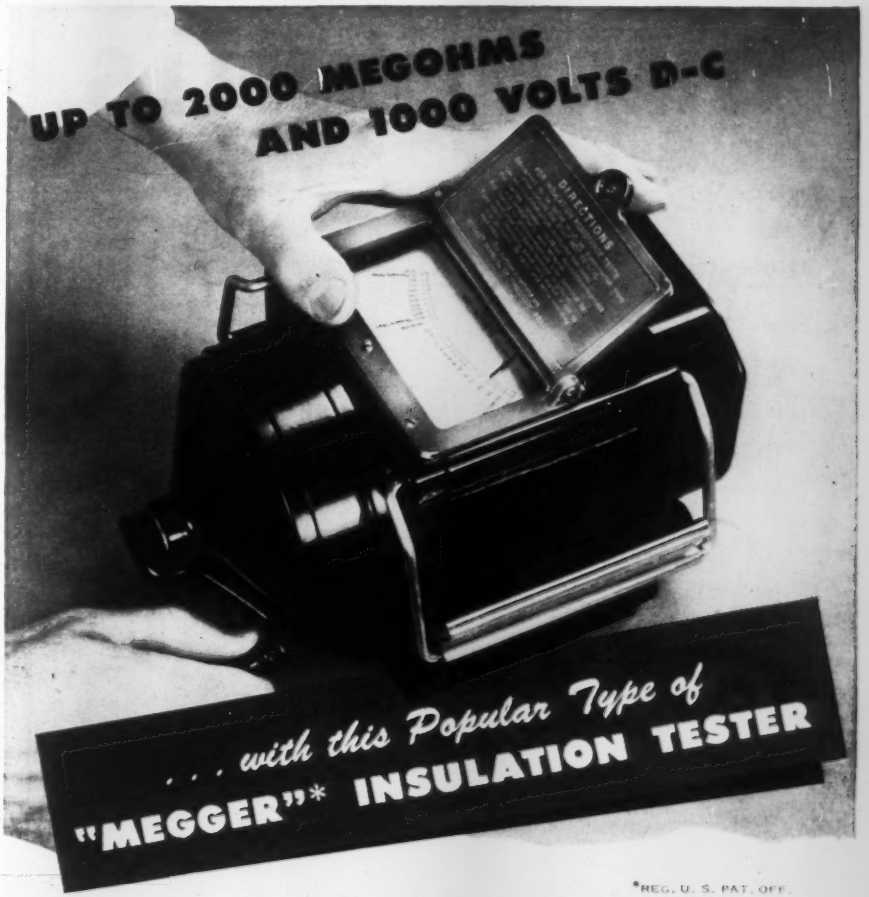

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ANYONE can measure electrical insulation resistance in generators, motors, wiring and other electrical equipment with a "Megger" Insulation Tester . . . quickly . . . easily. Merely make connections, turn the crank and read the position of the pointer on the scale.

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Other types of "Megger" Insulation Testers are available in various types with ratings up to 10,000 megohms and 2500 volts d-c. Write for descriptive illustrated Bulletin 1735-I.

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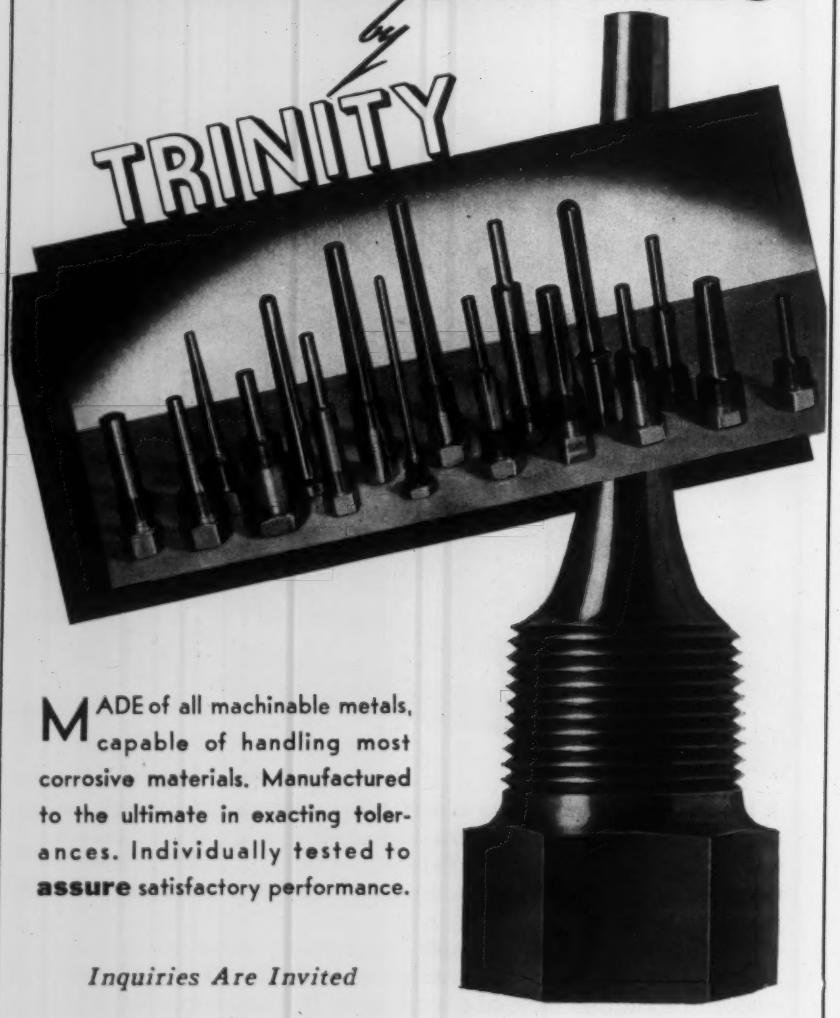

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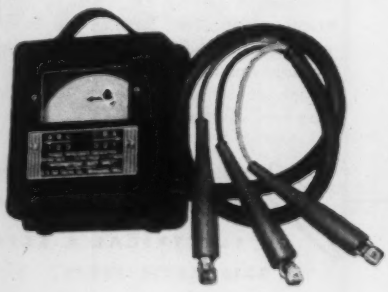
large field of vision and moderate magnification. "No. PX2" is a double-lens model for intermittent use, moderate size field of vision and greatest available magnification for large-area direct viewing. Indirect lighting is by two 6-watt 9" fluorescent "daylight" tubes. Units come ready to plug into any 115-volt 60-cycle outlet. (Instruments for use on other voltages, or cycles, or on d.c., supplied on special order.) Lens holder section, or head, may be tilted through full 360°. Side bracket arms are chrome-plated steel, with spring tension top and bottom, and adjustable at bottom through approx. 150°. Weighted base rests on ¼" thick flame-proofed felt. — *Mfg. Div., Larrimore Sales Co., P. O. Box 1234, St. Louis 1, Mo.*

Please mention number 838 when filling out card

Phase-rotation Indicator

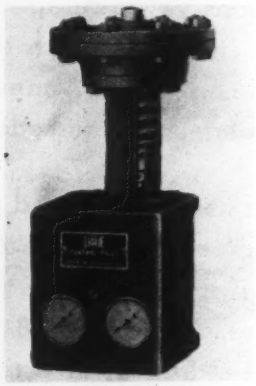
New "Model 32A Selco Phase Sequence Indicator" indicates phase sequence as established by electrical engineering societies, is designed for intermittent use on 3, 2 or 6-phase 25 to 120 cycles, 50 to 600 volts. (When used on 2-phase 3-wire, maximum voltage between two outside wires should not exceed 600 volts.) To "phase out" a 6-phase device, the six terminals should be grouped into two 3-wire groups with equal voltages between any pair of each group; the two groups then arranged with same phase sequence. Instrument operates with disk vertical or horizontal, its movement being suspended within cast-aluminum frame 5½" × 6" × 3"; is designed for severe service; is recommended for use by linemen, plant installation and maintenance men, repair crews, etc. Transformers are available. — *H. H. Sell Electric Co., 1907 Willow Ave. North, Minneapolis 11, Minn.*



Please mention number 839 when filling out card

Pressure Control Pilot

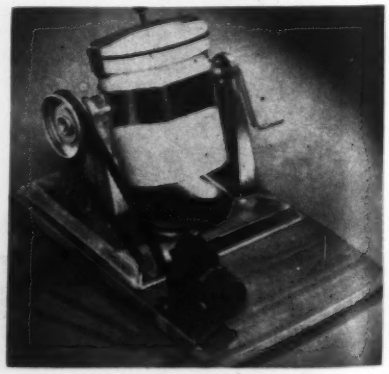
New "All-purpose Pressure Control Pilot" for use with diaphragm regulating valves is a simple and positive mechanical device used to control action of a diaphragm-motor valve so as to maintain a constant controlled pressure; regulates operating pressure (air, clean gas, water or light oil) to a standard diaphragm valve. Economical operation is said to be assured because there is no continuous leakage of operating pressure, particularly important for "stand-by" applications. New pilots are made in nine controlled pressure ranges from ½ to 800 lbs./in.^{2}.—*Leslie Co., 225 Delafield Ave., Lyndhurst, N. J.*



Please mention number 840 when filling out card

Tumble Jar

New Tumble-Jar is a motor-driven model. Powered by a gear reduction motor, it rotates a glazed chemical stoneware jar, 6" diameter by 8" high.



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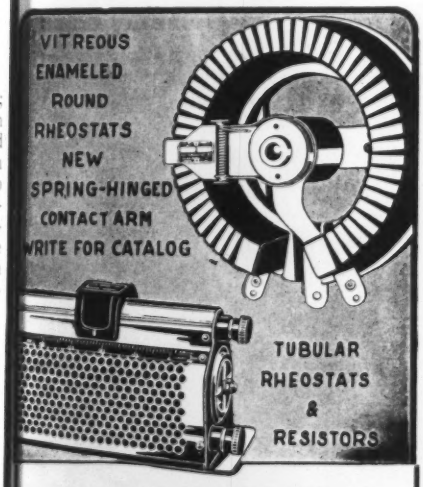

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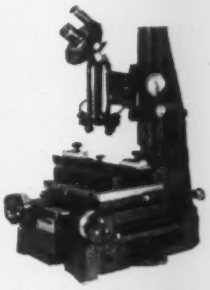

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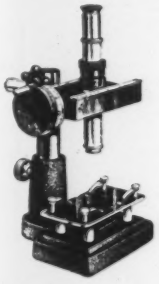

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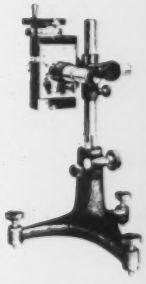

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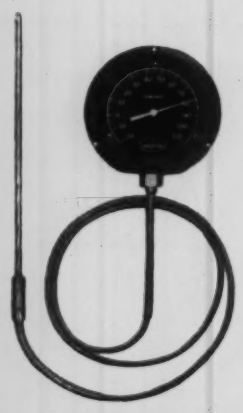

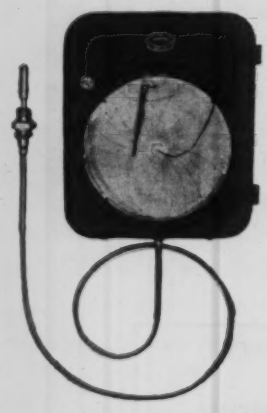

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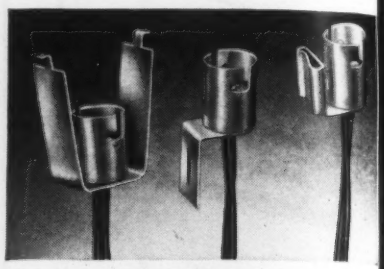
Head instrument man in large West Coast chemical plant with fifteen years' experience in industrial instrumentation covering flow, temperature, level, pressure, combustion control, SO_2, conductivity, continuous weighing, etc. Box 135, Instrument Publishing Co., 1117 Wolfendale Street, Pittsburgh 12, Pa.

at a speed of approx. 55 r.p.m. Owing to heavy weight of glazed jar, it can also be used as a ball mill. Jar has reinforced rim and stoneware cover which fits tightly against the soft rubber gasket by means of a metal clamp making it leak-proof in use. Overall dimensions are 14" × 22" × 15" high. Motor will operate on 115 volts a.c. 60 cycles or d.c.—*Andrew Technical Service, 111 East Delaware Place, Chicago 11, Ill.*

Please mention number 841 when filling out card

Lamp Socket Assemblies

New series of double contact candelabra bayonet type socket assemblies are Underwriter's Approved for 75W-125



service. Claimed advantages: No more vibration-loosened lamps; occupy less space; factory installed lead-in wires of any length from 2½" to 60"; supplied with any type mounting bracket of special design or with a choice of 10 stock brackets.—*Drake Mfg. Co., 1713 W. Hubbard St., Chicago 22, Ill.*

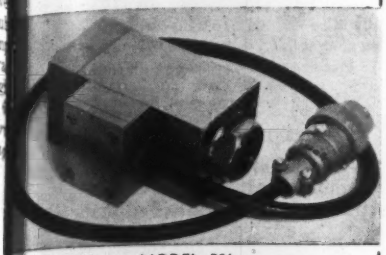
Please mention number 842 when filling out card

Corrosion-test Humidity Cabinet

New "Precision Corrosion Test Humidity Cabinet" is designed for testing corrosion of materials intended as cor-

rosive preventives. It produces a moisture-saturated atmosphere with continuous condensation on test specimens in accordance with Army-Navy Aeronautical Standard Specification #AN-H-31; may also be used for other tests where samples must be submitted to extreme temperature-humidity conditions. A revolving stage specimen rack, accommodating 33 test panels, rotates at ½ r.p.m. Cabinet is electrically heated and thermostatically controlled from room temperature to 150°F. (± 2°) and is

STATHAM
Pressure Transmitter



MODEL P21

The Statham Model P21 Pressure Transmitter is designed to measure differential pressures in systems with line pressure up to 10,000 psi. It is available in several different ranges from ±1 psi to ±10,000 psi.

These Pressure Transmitters are accurate, linear, simple in operation, reliable and rugged. With their high natural frequency, they are well suited to measurement of rapidly fluctuating liquid or gas pressures.

Auxiliary equipment requirements are simple. Power may be obtained from dry cells, or a stable A.C. source. The indicating instrument may be a panel type microammeter, recording potentiometer, recording galvanometer, or cathode ray oscilloscope. They are resistive in character, hence ideally suited for use with carrier systems.

Sizes: 1¾ × 2¼ × 4½ inches
Weight: three pounds

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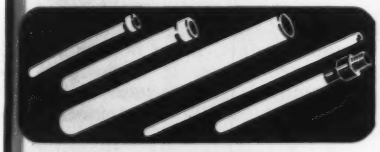
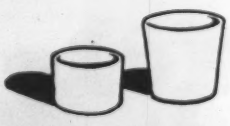


Montgomery high refractory tubes, porcelain, mullite and corundum, are widely used in applications above 2000°F. They are available in all popular and special sizes.

We also manufacture Crucibles for laboratory analysis. Tell us your requirements.



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Manufacturers of refractory porcelains

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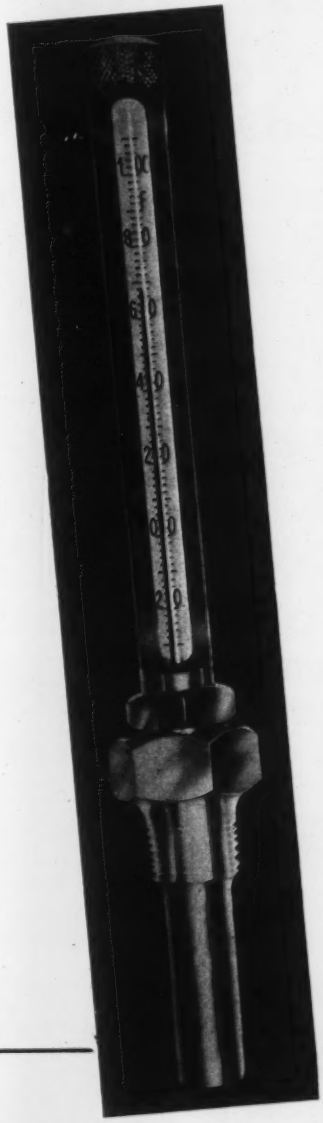

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NEW BELT SANDER FOR DRILL PRESS

Does Finishing Jobs Faster, Better

A new, simple, faster method for many surface finishing jobs on wood, metal, plastic and other materials has been announced by the OK Specialty Company of Chicago. The new finishing method takes the form of the OK Belt Sander, a drill press attachment.

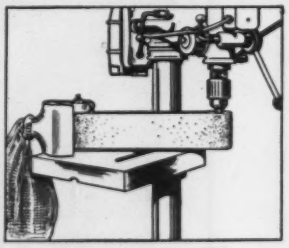
The new sanding device weighs less than 5 pounds. It is made up of an aluminum base with backing plate or platen, a driven pulley mounted on ground steel shaft and running on precision ground ball bearings, and cast aluminum driver pulley mounted on ½" ground steel shaft to fit into the drill press chuck.

The base of the sander is bolted to a drill press table. Merely by moving the drill press table, the attachment can be adjusted to handle sanding belts from 26" to 36" in length.

The sander takes belts from ½" to 3" in width. Two sanding belts, one coarse grit and one fine grit, are furnished with each attachment. The device comes assembled ready for use with any drill press. Most efficient performance is achieved at 3500 to 5000 RPM. The sander stands 5" high, and the base measures 10½" long by 3¼" wide.

Another time-saver on the job is chewing gum. Chewing gum may be used even when hands are busy; and under dust conditions helps to keep the throat moist—prevents "false thirst." For these reasons many plant owners make Wrigley's Spearmint Gum available to everyone.

You can get complete information from OK Specialty Company, 4655 N. Clark St., Chicago, Ill.



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AB-69

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equipped with air disperser and air flo meter. Interior walls are tinned copp exterior walls are plywood. Top co is hinged. Operated on 11 volts, cycles. — *Precision Scientific Co., 3 Cortland St., Chicago 47, Illinois.*

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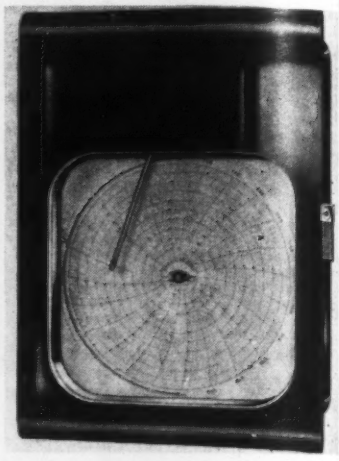
Thermometers and Gages

New "Series 500" line of record thermometers and recording ga utilize same operating principles



maker's previous recording thermo eters and gages but are housed in newly-developed case and incorpora many design improvements to ma them easier to use, more convenient service, and readily convertible fr one type to another. In addition, c struction has been simplified where possible. Case is so designed that it c be mounted on wall, front-of-panel flush-on-panel and can be easily c verted by user from one type of mou ing to another. Other case features i clude a heavy inlaid sponge-rubber do gasket, flush roll-type door handle a non-projecting door hinges. Mounti block which holds external connecti to instrument is removable: can mounted either on bottom or back case and changed from bottom to ba case or vice versa. It is designed f easy removal of measuring-eleme system. "Series 500" instruments a furnished in 8" and 12" sizes in a wi variety of ranges.—*The Bristol Co pany, Waterbury 91, Conn.*

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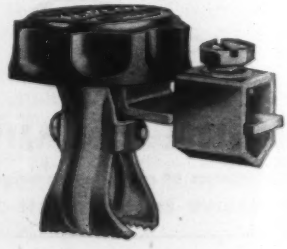
New "Trico U-66 All-purpose Kl lok Test Clamp" grips round or f objects up to 1" in diameter or widt is shock-proof, will carry up to 1 amps. continuously and 200 amps. i termittently. Solderless lug accomm



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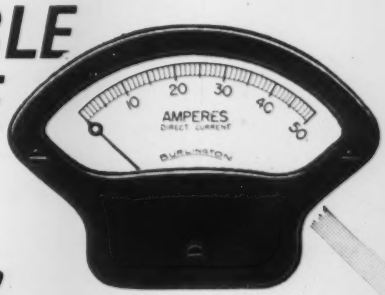

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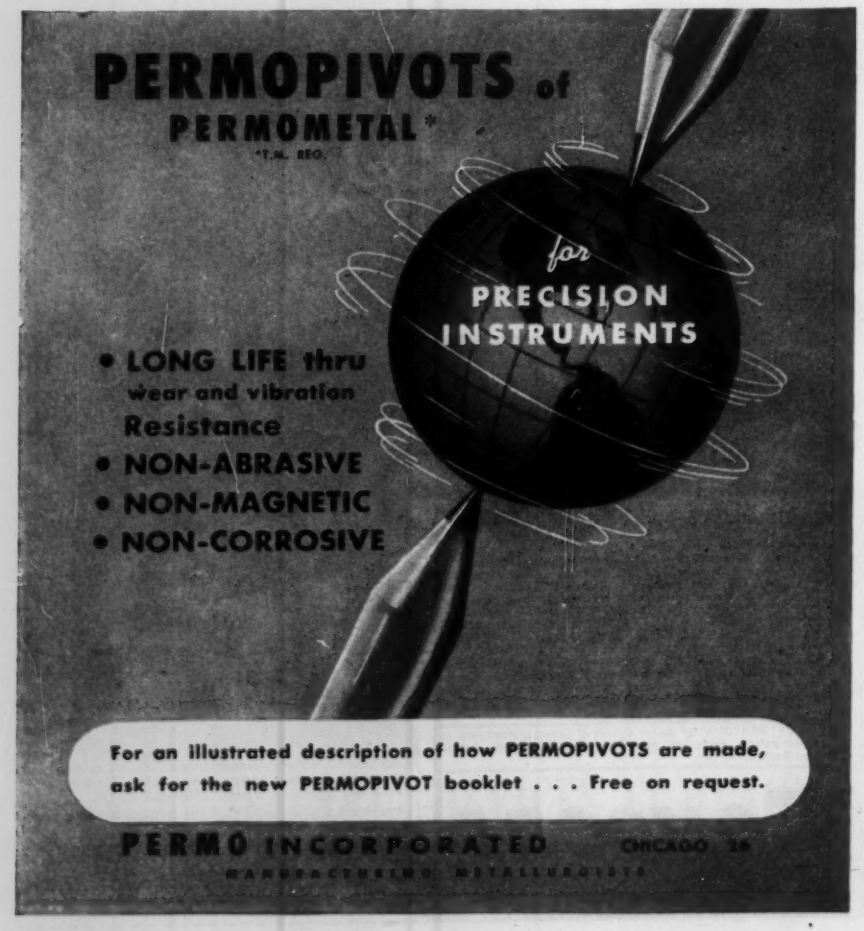

dates #2 wire minimum; #0 wire ma
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mitting wire or cable to hang in
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New full-scale Indicator Draft
Templets speed the task of Instrume
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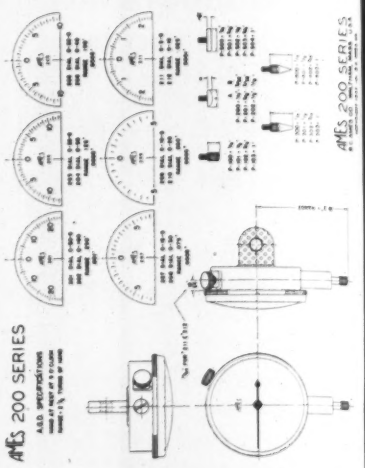

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on fixture drawings. They are black-o
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with six dial graduations for each siz
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of contact points; and necessary dime
sions. In use, templet with desired dra
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vellum, or tracing cloth. Maker wi
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New "Model 730 Vacuum Tube Vol
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a specific application at a specific pric
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to have every important feature of co
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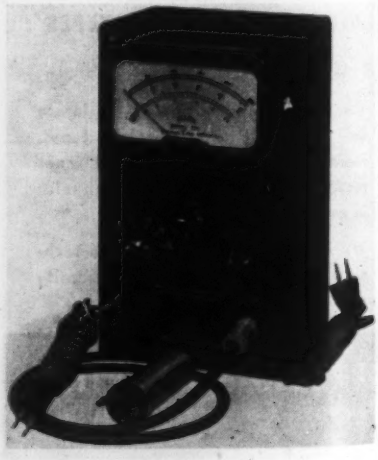

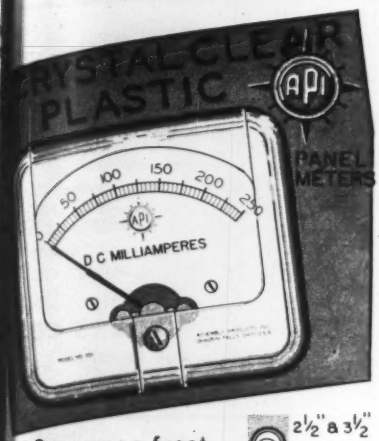

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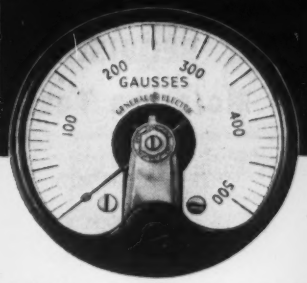

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Here is a new miniature magnetometer designed for ready measurement of the density and direction of flux in permanent magnets and d-c electromagnets—suitable for laboratory and shop use, for research and development, or production-testing of magnets.

Applications in which the gauss meter has been found useful are: checking flux density and distribution in electric-instrument magnets; checking flux density in arc blowout chutes, in contactor blowouts, and in voltage regulators; studying flux patterns about irregular-shaped magnets.

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This compact instrument can be held in one hand; for flux measurement there is probably no easier instrument to handle and operate. Its tiny prod, with a small area of sensitivity, enables the flux to be measured at what amounts to a single point in the air gap or iron structure—making possible a detailed analysis of flux distribution in any magnetic system. Since it does not depend upon voltages induced in a movable search coil, it is easier to use than the ballistic-type fluxmeter and permits more thorough investigation of magnetic structures. Write for leaflet GEA-4545. *Apparatus Dept., General Electric Company, Schenectady 5, N. Y.*

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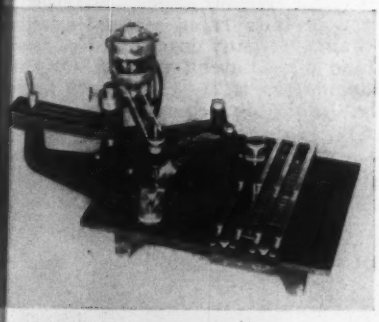

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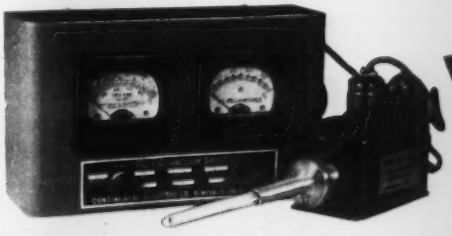

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VACUUM GAUGE
(Pirani Type)
For Accurate High Vacuum Measurement

Shown No. 6 Gauge

OUTSTANDING ADVANTAGES IMPORTANT TO YOU!

1. Gives instantaneous and continuous reading.
2. Range of 0 to 3000 microns.
3. Indicates presence of water and other vapors.
4. Indicates vacuum changes as they occur.
5. Adaptable to any high vacuum pump or system.
6. Easily placed at any point on vacuum system.

These D. C. operated gauges require only one or two No. 6 dry cells and may be installed in rubber, sealed to hard or soft glass systems or coupled to ½ inch standard pipe connection. Write for more complete information.

CONTINENTAL ELECTRIC CO.
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WHAT IS THE FIRST REQUISITE
In Standard Electrical Moisture Testing?

If you ask the Forest Products Laboratory, you will find . . .

1. Lumber must be probed physically with pointed electrodes, so as to tap directly the level of average moisture.
2. If electrodes merely contact the surface, and there is a drying gradient, the indicated percentage will be below the actual content. And the drier the surface, the more it insulates the wetter core and reduces the meter reading.
3. And this is true of any surface contactor, whether used with a conductance or a capacitance meter. And so, if a tester has only one contactor, it should have points.

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BULLETIN 181-1 TODAY

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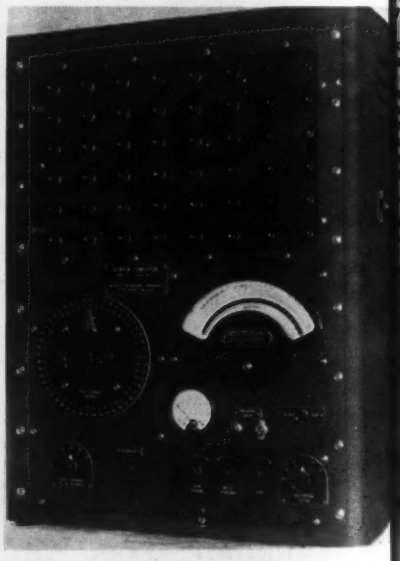

Fig. 1

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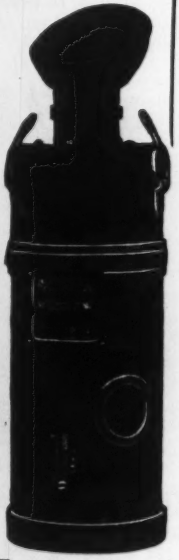

y using PYRO, a self-ntained, DIRECT EADING, sturdy uilt made to stand ough use. It is abso-tely accurate and pendable, and quick-pays for itself.

Unique construction nables operator to pidly determine tem-erature even on inute spots, fast oving objects, or allest stream; no rrection charts, no cessories, no main-nance expense. Spe-ial "FOUNDRY YPE" and "Univer-al TRIPLE RANGE" ave, in addition to tandard calibrated ange, a red correc-on scale determin-g TRUE SPOUT d POURING TEM-ERATURES of mol-n iron and steel hen measured in the pen.

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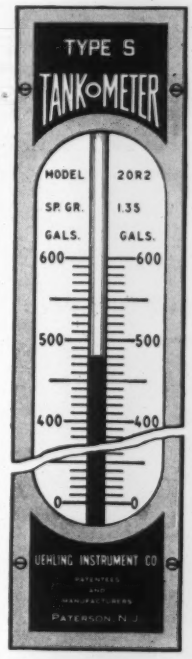

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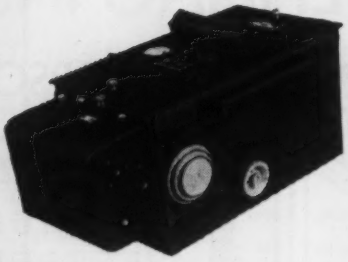

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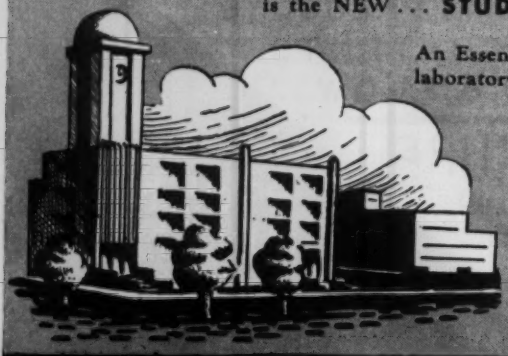

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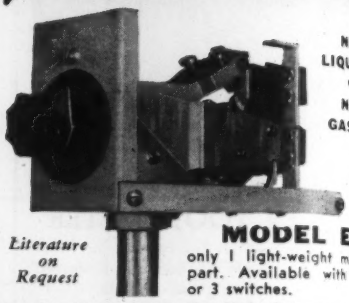
BURLING TEMPERATURE LIMIT SWITCHES



Literature on Request

MODEL E

only 1 light-weight mo part. Available with or 3 switches.

As a 3 switch model, Burling Model E is recomme for use (a) where load is divided into 3 parts, where 1 switch is used for controlling, one as a h limit, one as a low limit, (c) to give definite stop position to a 3 or 4 position diaphragm motor, (d give 3 speed control of variable speed motor.

Accurate, rugged, dependable. Corrosion and hea sisting tube. Dial pointer for easy setting. Lock screw locks temperature setting. Increased adjus range to 700-1000°. Dimensions: 7¼" x 2¾" x 3 Vapor tight base and cover with gasket available slight extra charge.

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Stevens Hotel, Chicago, Sept. 8-12th, 1947

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cated to left and tension to right of ze center. Cables with connectors are su plied for rapid connection of gage Built-in power supply operates on l to 125 volts 60 cycle a.c. All necessa automatic switching circuits are inclu ed in strain indicator so that as ma as ten indicators may be connected a single "Model 4 Strain Recorde

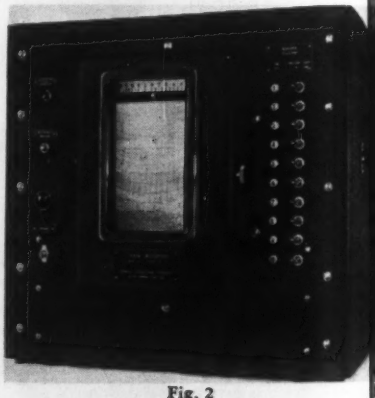

Fig. 2

(Fig. 2) to give ink-on-paper recordi of as many as 480 channels at the ra of three channels per second. Strai Indicator is housed in a metal tabl type rack cabinet 21" × 13½" × 28 high; weighs approx. 125 lbs. Strai Recorder is mounted in a metal cabine of matching style 21" × 13½" × 19¼ high; weighs approx. 110 lbs.—*Noske Engineering Products, Yellow Spring Ohio.*

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JOURNAL of the Instrument Society of America

Editor, R. R. PROCTOR, 2213 Ridge Ave., Evanston, Ill.
I.S.A. National Office, 1117 Wolfendale St., Pittsburgh 12, Penna.

Vol. 20 AUGUST 1947 No. 8

Editorial

On Making Your Conference Trip Worthwhile"

Appropriately enough our "sermon" or this month concerns the Second An- ual Instrument Conference and Ex- bit to be held at the Stevens Hotel in hicago next month (September 8 to , to be exact), and which event will istory by the time the next issue he JOURNAL makes its appearance. Inspiration for this little soliloquy mes from Pittsburgh in the form of opy of the MELLON INSTITUTE NEWS May 22, 1947. With due credit to publication and to our friend John Bowman, one of its Associate Edi- , we herewith quote from Mr. Bow- n's editorial in that issue. In fact, e the subject is so timely, and since Bowman handled it so admirably his editorial, we can do no better to reprint it verbatim, to-wit:

. . We have been to two large tech- l meetings recently, and . . . have e to the conclusion . . . that few ientists know how to get fullest ad- antage from them. The main object of ch trips, if they are to be considered siness trips, is to exchange informa- on; with that in mind, several do's don't's seem obvious.

The worst and most frequent sin is sociation with co-workers! At one eting the delegates from one large ustrial laboratory, about six strong, re always to be seen together; they ved as a group, ate together, heard bers together, and apparently talked each other almost exclusively. This ounts to misappropriation of funds! t only did these men duplicate each er's gains, but they missed a good nce to get wide coverage of the eting. Surely there is little to be ned by going to a distant city to dis- s anything with someone you can any day at home." (The Exhibit npensates to a great degree, but the rument still holds.—ED.)

Lack of acquaintanceship with ers is no excuse. No third person is essary to perform introductions at h events. It is perfectly good form introduce yourself to a total strang- and discuss your common fields of search with him. Never hesitate to op and stare to read a man's name his badge. Even the most distin- ished of the old guard are flattered be approached and questioned about eir work, and contacts made that way e valuable assets. We observed one an who kept looking at his watch ring an informal conversation; he ex- ained that he was much interested in certain paper, and was anxious to et to that session, *as soon as it was* er, to corner the author, whom he did ot know.

"Which brings us to the papers themselves, and another don't:' Don't just settle down for the complete session of the division covering your specialty, taking copious notes all the time. The average research worker is rarely concerned directly with more than a few papers out of the many presented, and these will be published soon in technical journals which the specialist follows anyway. A much better practice is to hear papers in fields bordering on your own, papers that you would not ordinarily read in the routine of keeping up with the literature on your specialty. Such papers are frequently inspirational, suggesting new twists and tricks that can be applied in your own limited field.

"In short, avoid the routine, strike out on your own, and go after what you went for, being as helpful to others as you can along the way."

To Mr. Bowman's pointed remarks we add our second, and toss in the suggestion that each person attending the forthcoming Conference in Chicago make it a point to make as many new acquaintanceships as possible during his stay. There will never be a better opportunity to build up one's assets in the form of information and business contacts, the benefits of which will continue to be felt and appreciated long after the Conference is over.

See you at the Stevens. —RRP

Editor's Notes

1. Who's Who

Our "Who's Who" department this month is devoted to two Section Delegates and two Chairmen of subcommittees of the Recommended Practices Committee. We regret that the material on the officer-of-the-month was delayed and will have to be held over until next month, but to make things interesting we chose to publicize the two delegates who have respectively the shortest and longest names among all the delegates of the Society. These gentlemen are the Messrs. Lee of Cleveland and Goetzenberger of Washington, two very active members of the Society.

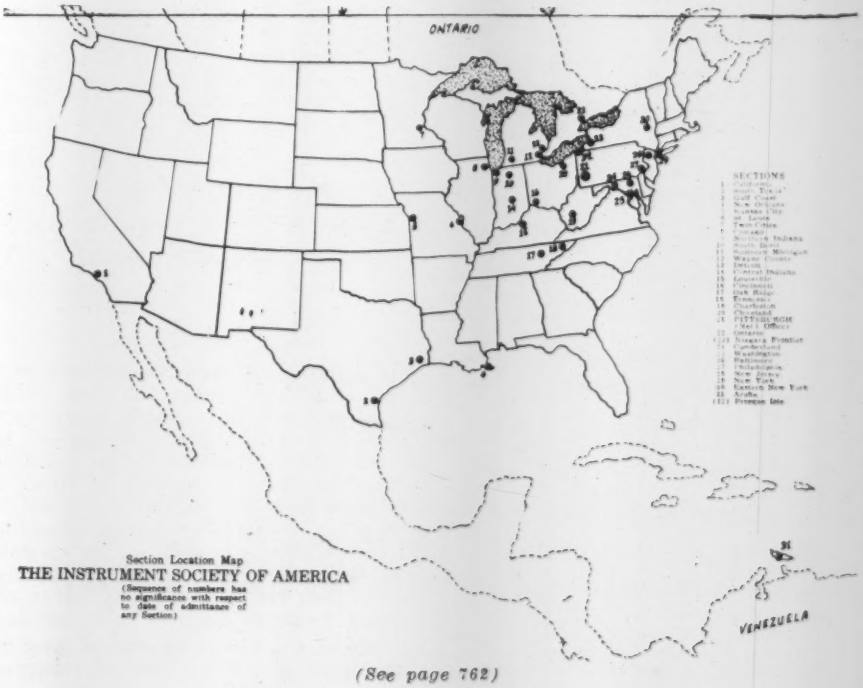
The two subcommittee chairmen of the Recommended Practices Committee whose projects are probably the nearest to completion are Dr. William G. Brombacher and Harold M. McCarthy, heading up respectively the subcommittees on Manometer Tables and Recommended Practices for Thermocouples and Thermocouple Extension Wires. Since material from both these committees is expected to be published soon, we thought this would be a good time to introduce these two busy gentlemen.

2. Open House in Chicago

Many people planning to attend the Second Annual Instrument Conference and Exhibit in Chicago next month have expressed interest in visiting some of the instrument manufacturers' plants and factories which are located in or near Chicago. According to Nelson Swarr, chairman of the Plant Trips Committee, arrangements have been made with all such firms so that anyone interested in inspecting these plants need only go there and they will be taken care of.

The scheduled plant trips arranged by this committee will be taken Friday afternoon, September 12, and include trips to the Standard Oil Refinery in Whiting, the South Works of Carnegie-Illinois Steel Cor-

(Continued on page 762)



Section Location Map
THE INSTRUMENT SOCIETY OF AMERICA
(Sequence of numbers has no significance with respect to date of admittance of any Section)

(See page 762)

Progress In Quality Measurement For Process Contro

By NELSON GILDERSLEEVE, Special Products Division, Apparatus Depart., General Electric Co.

AT THE TIME when the first atom bomb fell and the Smyth report indicated the tremendous strides that instrumentation had taken during the war years, a new era of instrumentation seems to have been born. Some of us call it not born, however, but grown up here; others merely speak of a future birth. Dr. Ralph Munch of the Monsanto Chemical Company's Research Laboratory, writing in *Industrial and Engineering Chemistry*, has stated: "The greatest unfilled need of the chemical industry in the field of instrumentation is for devices which can give a continuous analysis of a flowing process stream." The instrumentation era that approaches is the era of direct, continuous measurement and control of chemical composition to replace many inferential methods now in use.

Most of us in thinking of process instrumentation or process control define it as the measurement and control of non-electrical variables; some of these variables are temperature, pressure, flow, and liquid level, the war horses of process control, the tried and true measurements upon which most processing has been based for years. Let us add to these variables conductivity, pH, humidity, electromagnetic radiations (ultraviolet, visible, infrared), speed, tension, time, and vacuum. This gives us a list of the important *measurable* (and hence *controllable*) *processing conditions*. We might safely add certain other measurables, such as dimension or weight, or position of components of processing units, which in some cases are processing conditions. Examples may be found in extrusion, rolling, and other working and forming processes.

Let us make another list—this time a list of measurable *properties* of products which are being processed in industry. Such a list includes:

Analysis or composition	Mass or molecular weight
Calorific value	Moisture content
Color	Refractive index
Consistency	Specific gravity
Density (gravimetric)	Tensile strength
Dielectric strength	Thermal conductivity
Elastic limit	Turbidity
Viscosity	Ultrasonic absorption

These properties, both physical and chemical, are related to product *quality*. No matter whether we have a piece of steel, rubber, or soap; a bottle of beer, perfume, or hair tonic — there should be some measure of the quality of the products before they are sold or utilized in further manufacture.

Quality acceptance tests measure specific properties of a material; since the material has come through a process, the measurement is of *what has been done*. Good processing demands measurement and control of *what is being done*. Temperature, pressure, flow and the other variables associated with them set the processing conditions. True it may be that a product will be of unsatisfactory nature unless the processing temperature is held at 900°F, but the holding of the temperature at that point does not in itself guarantee that the product will be satisfactory. Thus a continuous quality measurement, whose control action resets the processing conditions controls, is a processing aim.

The application of the measurement of physical and chemical properties in process control is not always direct or straightforward. Many studies have been made of process lags and control responses for *processing condition measurements*. Beyond these studies are those required for *quality measurements* — the determination of which processing condition controls must be reset, how much, and in what proportion to each other, if there is a deviation in quality from the desired value.

Let us take as an example of a quality measurement control system a bleaching process in which the color of the fluid stream emerging from the process is a direct indication of the degree of bleaching and, therefore, the quality of the paper stock at that point in the manufacturing process. (See Figure 1). Raw stock and chlorine water are mixed in a mixer and flow upward through a chlorination tower for a period of about 60 minutes at a temperature between 70° and 80°F. Tapped from beyond the mixer is a sample flow line through which part of the mixture is pumped to a retention chamber where it is held for about 3 minutes at 110°F. Beyond the retention chamber is the color control indicator. By measuring the color of the product on the sampling line instead of the main line, the measurement lag is reduced from 60 minutes to 3 minutes.

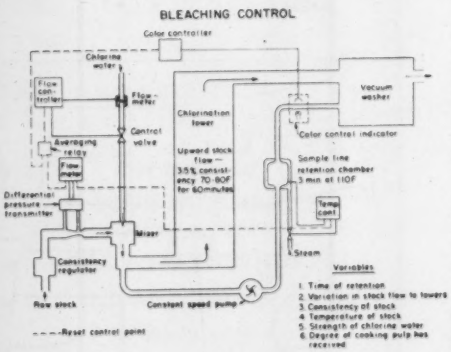


Fig. 1

Six of the bleaching control process variables are: (1) Time of retention in the chlorination tower, (2) variat in stock flow to the tower, (3) consi ency of the stock, (4) temperature the stock, (5) strength of the chlor water, and (6) the degree of cook the pulp has received. If there many variables that will affect qual as there are here, the more that be controlled by action independent the main quality measurement, the complex is the control associated w the quality measurement. The ba control function in the system here lustrated is to maintain the prod of bleaching time times chlorine wa strength (defined on a per unit of st basis) constant.

The stock retention time is assum to be an inverse linear function of stock flow to the tower, and the ch rination tower temperature is cons ered to be held constant at the prop processing temperature. With a creased flow of stock, the stock will main longer in the chlorination tow and suffer a higher degree of bleachi The retention chamber temperatu controller is therefore reset by the fl controller to increase the temperatu in some proportion to the decrease flow. This action restores the sam line output to a reflection of the ma tower output quality.

To reduce the number of variables fecting the final quality, a consisten regulator is used on the raw stock li to hold the stock consistency relative constant; a change in quality at t measuring point will not, therefore, the result of a change in consisten

The flow diagram shows no reg lator for holding the strength of t chlorine water constant; since the w ter strength is a most important va able affecting the process, we sh use the color control indicator as t primary element for chlorine wat strength measurement; its strength w be controlled on the basis of the v ume of chlorine water introduced i the mixer. The use of the color cont indicator in place of a regulator the chlorine line introduces a fix time lag of about 3 minutes.

Another variable is the degree cooking that the pulp has receive Again, the flow diagram shows no p mary element for this variable exce the color control indicator which w observe a darker solution if the pu is under-cooked, showing that with t process controls as set sufficient bleac ing is not possible. The color cont indicator must use the amount of ch rine water added to the process as means of correcting for undercookin

Since the amount of chlorine wat to be added is a function of the sto flow as well as of the degree of sto cooking, we see that the control setting action from the color cont indicator and the raw stock flow co troller must be combined in an avera ing relay to give a single output

*Presented at the Spring Meeting of the Instrument Society of America, Cleveland, Ohio, April 24, 1947.

NOTE: Statements and opinions advanced in papers are to be understood as individual expressions of their authors and not those of the Society.

et the chlorine water flow controller. course, the prime function of the w controller is to hold the flow con- nt at the desired value.

f we think of this process only from point of view of product quality asurement, we find that the color in sampling line is such a measure- nt; also that the degree of cooking d the consistency of the raw stock ect the quality, as does the strength the chlorine water. When we recog- e that a quality measurement may used to reset several processing con- ions controls as well as other qual- measurement elements, which in rn reset condition controls, then we d that instrumentation may become plex.

t hardly seems necessary to point that the development of quality asuring devices means great coop- tion between plant process engineers d instrument application and design gineers. A very thorough study of process and the composition of the mponents in the process is required; s intense study may bring improve- nts in actual materials processing.

Let us look at some of the quality asurement tools available today, and tice which ones are laboratory tools ly, which are installed on the proc- line, and which are in transition. t so many years ago, these instru- nts were all laboratory tools. This t is neither unusual nor illogical, for cialized instrumentation with very w sales volume means high manufac- ring costs. Broad markets until now ve not been sufficiently visible to jus- y the high engineering cost of prod- t design for semi-mass production.

To limit the scope of of this discus- n, most instruments whose readings found on a photographic film, on slide rule, or in a microscope have en excluded. The output of the quality easurement primary element should directly applicable to a process re- rder and controller.

Our first variable is material com- sition, and in this we refer to mate- ls in which we are not looking for chemical analysis, but for a compara- e analysis generally for a single im- rity such as conducting particles in sulating materials; air pockets, which may call porosity, in strip steel; or absence or insufficiency of a com- nent such as carbon in certain steels, missing parts in an assembly.

The magnetic comparator for fer- us material comparison normally es two 60 cycle air-core coils whose actance is compared by a balanced rcuit. When the reactance of one coil, this case the test coil, differs from at of the other, the reference coil lding the standard part, there is an tput current to an indicating instru- ent. The reactance of a 60 cycle coil ries with the permeability of the ma- rial within the coil. Assuming that e have magnetic material, the per- eability may be affected by composi- n, by degree of heat treatment, by rdness, and by other factors.

If we are continuously drawing steel ire which must have as high a tensile rength as possible, yet requires a rtain softness for bending, the wire ay be drawn through one coil of the magnetic comparator. If the bendability of the wire is correlated as a function or such a specification might apply to insulation actually on wire. Plastic sheets might be allowed a specified number of points per unit length where the dielectric strength could be below a given value, or rubber sheets might be allowed a certain number of pinholes per given length. The Fault Detector (Figure 2) consists of an electrode assembly in contact with the material to which a high potential is applied and an electronic circuit which detects the slightest flow of current through the material which is allowed by either a hole, a thin spot, or a conducting particle. The power is current-limited so that there will be no burning of the material or enlarging of the holes at the points at which flaws occur. The potential can be varied over a wide range and can be set anywhere between zero and a value that will continuously break down sound material. There is an automatic counter to record the total number of faults. Thus we have a true quality control measuring device which must normally be used in conjunction with manual controls to maintain product quality at specified values.

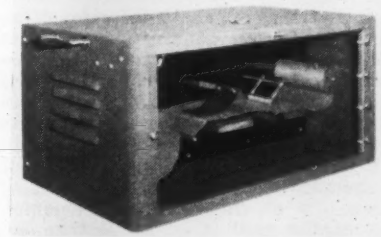


Fig. 2. Electrode Unit for G-E Fault Detector.

of the heat treatment, which in turn affects the permeability of the wire, then a continuous indication may be secured of the degree of bendability of the wire. An automatic control can be arranged to correct for any deviations from the desired value.

A high frequency metals comparator, designed especially for the application and not yet available commercially, has been used to inspect chain and to ring an alarm every time a section of chain passes through the detector coil in which any part, such as a link, pin, washer, etc., is missing. While it is not possible to reset any parts-feeding machines or use the alarm to single out the specific operator at fault, frequent alarm operation will alert all the operators along the line and be an incentive to more careful assembly.

A new instrument permits the setting of performance specifications for capacitor paper which might allow a certain number of conducting particles or weak points per 100 ft. of paper;

The application of ultrasonics has had insufficient exploitation as a processing tool. We recognize the use of ultrasonics in the emulsification of immiscible liquids. Ultrasoncis is being used in the manufacture of catalytic agents where there must be a dispersion of metals in liquids. A 700 kilocycle frequency has been useful in the splitting of highly polymerized molecules. Ultrasonics is used in speeding the solidification of certain metals, in the vibration of metals being coated to give a more dense coating, and in the degassing of liquids.

If a transmitting crystal is placed on one side of a sheet of steel (Figure 3) and a receiving crystal on the other side, either in close proximity to or within a conducting medium, the ultrasonic transmission can be indicated. Poor transmission means flaws, voids, or porosity in the sheets. The transmitter and receiver can be mounted within a pipe in contact with the process stream, and the amount of ultrasonic absorption by the process stream continuously indicated. Wherever ultrasonics is used as a processing tool, a device for measuring ultrasonic absorption must be available, first as a quality control instrument for acceptance tests on a sampling basis, and second as automatic control to regulate the main ultrasonic generator to give a constant ultrasonic absorption to the output fluid.

Viscosity is a process variable for which many attempts have been made to develop automatic equipment. Of the few recognized continous viscosimeters available today, one operates on a rotameter principle. In the viscosimeter are two flow-sensitive floats, one which is viscosity immune and the other viscosity sensitive. The lower viscosity-im-

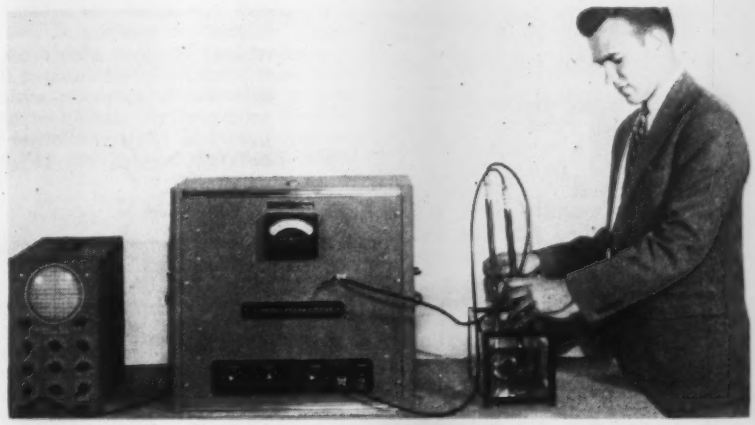


Fig. 3. Ultrasonic Materials Tester for indicating voids, cracks, or flaws in metals, plastics and ceramics. Tester consists of ultrasonic transmitting and indicating unit (center) and two transducers (right). Standard oscilloscope (left) is optional accessory.

mune float will take a position in the rotameter solely due to flow. The upper float will take a position in the rotameter due to flow and viscosity. The difference between the position of the two floats is a function of the viscosity. To use the viscosimeter for controlling purposes, a flow controller is placed in advance of it in the line. The viscosimeter whose float position with constant flow recognizes only viscosity changes can be used for automatic control based upon a position measurement of the float.

Specific gravity of a fluid is important in many processes, for instance, in the manufacture of alcohol or heavy acids. The liquid to be measured continuously passes through a closed glass chamber in which is a hydrometer float containing an iron core. The hydrometer float rises and falls in a tube with changes in the specific gravity of the fluid only, and is not flow sensitive. The iron core is surrounded by a transmitting transformer connected to the recorder. Immersed in the flow tube is a resistance thermometer bulb which provides temperature compensation at any desired reference temperature through a network which automatically feeds the recorder input circuit so that specific gravity is recorded as if the process fluid were at constant temperature.

The moisture content of materials cannot yet be universally measured. We who are consumers of sugar and other food products, users of paper and textiles, purchase water in these products. The difference between financial success and failure for the manufacturer or processor may depend upon the amount of water which can be sold as a part of the product. The man who sells too dry a product sells too much quality at too low a price, and may find too stiff the competition of those manufacturing with the legal limit of water.

Two quite different primary elements are found measuring and controlling the moisture content of paper. The first measures the electrical resistivity of the paper. Two opposing arms of a wheatstone bridge have fixed resistors. The third arm is the balancing slidewire of the recorder. The fourth arm is the paper resistance, which is actually the resistance between a detector roll and the machine roll over which the paper passes. The output of this null balance circuit is amplified and used for bringing the bridge to balance. Each individual paper must have its own calibration curve for the controller; once the controller is set for a given paper, it will control for that paper only.

The other moisture detector employs a small shoe which rides on the paper. Within this shoe is a capacitor element of two concentric perforated plates with hygroscopic material between. The moisture, as the manufacturer states, is electrically weighed and the output recorded and used for controlling the steam flow to the paper dryer.

In speaking of consistency as a process variable, I am led to think of Lord Kelvin's oft-repeated statement "I often say that when you can measure what you are speaking about, and express it in numbers, you know something about it." Many processors are not able to define consistency in terms as clear to them as degrees centrigrade, inches of water, percent carbon tetrachloride, or RPM. Many speak of consistency but mean viscosity, or specific gravity, or some undefinable comparison with a common substance. A Thin Stock Consistency Regulator is particularly valuable for consistencies below 1¼% of paper stock where the consistency-viscosity relationship is too flat a curve. Stock from a constant head source at a constant flow rate is carried into a chamber in which there is a rotating perforated cylinder. A web forms on the top half of the cylinder circumference. The water flows through the perforations, depositing solids on the cylinder, and out the other side where it washes off the web. The flow of water is retarded in proportion to the web thickness on the cylinder and, therefore, the consistency. This retardation changes the head of water within the chamber ahead of the cylinder as a function of the consistency. The head is measured by a bubbler tube.

The greatest advance in instrument development today is being made in instruments for chemical analysis. They may be divided into four groups:

1) Spectroscopic instruments, which are subdivided into two sections, emission and absorption spectroscopy instruments. In absorption spectroscopy are instruments in the microwave, infrared and Raman, visible, ultraviolet, and X-ray portions of the spectrum. These instruments can generally be used for solids, liquids, and gases. Emission spectroscopy is more concerned with metal analysis than continuous fluid analysis, and therefore it is not a real factor in automatic control.

2) The second group is a single instrument, the mass spectrometer, known frequently as the "electronic chemist," the master analyst of all instruments, used for gases or liquids vaporized in a high vacuum.

3) The third group contains thermal conductivity, hot wire, acoustic, and density devices, normally applicable only for gas analysis of 2 or 3 component systems and refractive index.

4) The fourth group includes devices specific to a single element or compound, such as water vapor, mercury, carbon dioxide, carbon monoxide, hydrogen sulphide, or oxygen. It is not that the devices in the first three groups cannot be specific to a single element or compound, but that these devices in group 4 have been designed to analyze for one compound, or because of their principle of operation can detect only a single element or compound.

Somewhere in the electromagnetic spectrum practically all substances possess a selective absorption which can be used as a positvie identification, even in the presence of many other materials. The visible spectrum (Figure 4)

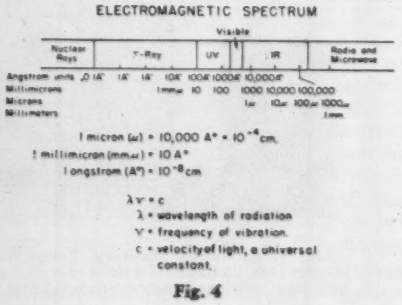


Fig. 4

is the smallest wave length terval the electromagnetic spectru exte ing from about 400 to 700 m limicro The visible and X-ray reg ns are present the least used in che ical an ysis. Absorption in the X- y reg is an atomic phenomenon, while in other regions it is molecular The m useful regions for hydrocarbon analy are in the ultraviolet from about to 275 millimicrons and in the infra from about 2.5 to 25 microns.

The absorption of X-rays is in pendent of the physical state of matter being traversed by the X- radiation. X-ray spectroscopy is p ticularly desirable in those proces with a controlling component which of considerably higher atomic num than the atomic numbers of the ot components.

The X-ray unit of the X-ray photo eter (Figure 5) generates a be

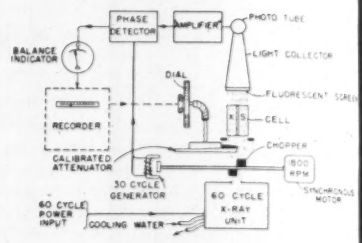


Fig. 5

which is interrupted by the synchro ous motor-driven chopper so that ha the beam alternately passes throu cell X, which is the test cell, and cell the standard cell, and impinges on o side or the other of the fluoresce screen. Light from the screen is r flected by the mirror walls of the lig collector to the phototube, whose el trical output is amplied and fed in a phase detector.

The synchronous motor also dri a 30 cycle generator whose output fed into the phase detector. The dete tor action is such that it converts t inputs from the phototube amplifi and the 30 cycle generator to a dire current whose magnitude and directi depend upon the relative intensities X-rays transmitted through X and

A calibrated wedge-type variable a tenuator disk may be manually rotat in the beam to insert a known absor tion, depending upon the angular po tion of the disk. The balance indicat can thus be brought to zero output, i dicating equal absorptions in the t beams. Therefore, the position of t disk may be calibrated as a direct i dication of the difference in absorpti of the two samples.

The analysis can be made complete automatic with a potentiometric recor er. The recorder servo-motor is mecha ically coupled to the attenuator di and the conventional slidewire fee back is eliminated. The recorder inde will move until there is zero inpu When the recorder is used in sut fashion, there is sufficient power to u the indications of the recorder to co trol the process if the sample at X representative of the product.

The sensitivity of this method analysis varies generally from 0.01 to 1% of actual concentration of an el

t, depending upon the difference in
nic numbers of the elements in-
ed. For instance, the concentration
lead or mercury in organic com-
nds is determined within 0.01%.
ever, the concentration of argon
itrogen can be determined to only
%.

ltraviolet spectroscopy is more use-
as a rule for inorganic than organic
nicals. However, molecules includ-
the benzene ring, such as benzene,
ene and xylene, are normally read-
dentified through use of ultraviolet.
use of the ready availability of
cury light sources and phototubes
onsive to 2537 radiation, much
k has been done in this region with
er simple instruments which are
photometers by definition and which
not designed for process work.
cury and trichlorethylene in toxic
ts are very easily measured.

Northwestern University has recently
veloped an automatic recording ultra-
let photometer. Its particular appli-
ion has been in the detection of
sgene, chloropicrin, and nitroben-
e, all of which show high absorption.
e device uses a mercury vapor lamp
ing 2537 radiation and a RCA935
otomultiplier receiver. The circuit is
l balance. The unbalanced amplified
tage between two photocells, one of
ich looks at pure air and the other
the test sample, is recorded on a
E. photoelectric recorder. The pho-
meter is suitable only for gases which
orb 2537 radiation.

There are two well-known spectrome-
for measurement in the visible
ge. The G.E. recording photoelectric
ctrophotometer, which is based on
original design of Arthur C. Hardy
MIT, covers the range from 400 to
millimicrons. A Quartz Spectro-
tometer covers the spectrum from
millimicrons in the ultraviolet
rough the visible to 2000 millimicrons
the infrared.

The G.E. Spectrophotometer (Fig.
is shown diagrammatically. The

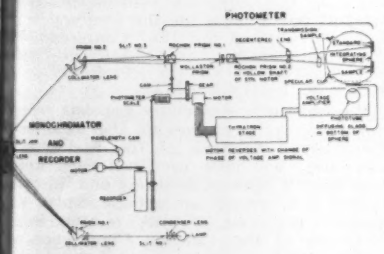


Fig. 6

nt source radiates all wave lengths
the visible spectrum. The light is
persed by prism 1 into a monochro-
tor which passes a constant wave-
gth band of 10 millimicrons and
ries the particular band across the
ible spectrum. The monochromator
connected directly with the recorder
art drive through a gear train to
ke one axis of the spectrophotome-
c curve wavelength in millimicrons.
e light is further dispersed by prism
and trimmed by slit 3 to insure its
ectral purity, and then is passed
rough the polarizing and flickering
tical system of 3 prisms into the in-
tegrating sphere where it falls alternately, 60 times a second, on the sample and on the standard. If the light reflected by the two is equal, the phototube sees a constant light level; if the reflectance is not equal, the phototube will see light variation at the rate of 60 cycles a second. This 60 cycle voltage signal is amplified and applied to a thyratron stage to drive a small split-field motor which is connected through the photometer cam to rochon prism 1. This "balance" motor rotates the prism, which changes the light intensity on the standard with respect to the sample until the light reflected by the two is equal. The position of the rochon prism and of the pen which is on the same shaft is then an accurate measure of the difference in reflectance between the sample and the standard. The measurement is always made at the point of zero voltage signal and is, therefore, independent of the characteristics of the phototube, lamp, and amplifier, thus being a true null system.

In chemical analysis work, of course, we are concerned with transmission samples which are liquid; because of this, two white reflectors are used in the standard and the sample holders, and varying absorption between the two reflectors is established by the transmission sample which is placed in one light path, and which varies the amount of light incident upon the "sample" reflection block in accordance with the color of the transmission sample. Neither continuous sampling nor continuous measurement at any narrow band width exists in the standard instrument, but the way is pointed by the spectrophotometer for such measurement and control for the process industries.

A Recording Photoelectric Quartz Spectrophotometer is a modification of the Quartz Spectrophotometer which makes possible continuous automatic analysis of liquids or gases. As ordinarly furnished, the instrument measures continuously the per cent light transmission of a sample using monochromatic light at any fixed wavelength between 220 and 360 millimicrons; with a different light source and phototube, it may be used up to 2000 millimicrons.

Per cent transmission of the sample is recorded directly with an accuracy of plus or minus 1%. Automatic repetitive standardization to compensate for changes in light output is a feature of the device. Every five minutes a transparent reference gas or liquid is passed through the spectrophotometer, and the phototube amplifier is automatically adjusted so that the recorder reads 100% transmission. Thirty seconds each side of this period are devoted to purging, so that the recorder records per cent sample transmission for 3½ out of 5 minutes.

Infrared analysis now seems to hold the most promise of the absorption methods for widespread application to the process line. It is particularly useful in organic work where a variety of types of linkages, structural groups, and spatial configurations are present in various organic materials. There are in service in the United States probably several hundred infrared spectrographs, whose chief value is in making analysis, both qualitative and quantitative, of highly complex hydrocarbon mixtures, involving quantitatively both process analysis control and measurement of reaction rates.

What can be done with spectroscopy in the analysis of hydrocarbons is at present limited by the lack of availability of certain pure hydrocarbons for calibration and determination of spectral characteristics, and by the lack of strong, stable energy sources and adequate energy detectors. The latter needs are important even when null-balance circuits are used.

There are applications where the infrared absorption peaks of the various components of a product are so spread out, and where only one peak is of interest, that a photometer either with or without a monochromatic light source may be used in preference to a spectrophotometer for measurement on a continuous basis, a preference based on considerable price advantage. One such infrared gas analyzer uses two balanced infrared beams from one source focused on bolometer arms which are part of a Wheatstone bridge circuit. Unbalance of the bridge is a measure of the difference in absorption between the sample and the reference cells.

A stream of gas at constant pressure passes continuously through a cell covering both beams. A high concentration of the critical gas or the gas to be measured is maintained in a filter cell covering one beam and one bolometer. Any absorption of energy by the various components of the process stream has a differential effect on the bolometer elements only the the absorption occurs in a portion of the spectrum in which the filter absorbs. If a complicated gas system contains constituents with overlapping bands, filters of the interfering bands are inserted in both beams. Thus a knowledge of the concentration of all components of the gas system is essential for optimum use of this analyzer. Measurements should be made at room temperature on gases which are present at pressures well below their vapor pressure at this temperature.

The mass spectrometer is the master analyzer or master chemist. Its principle of operation is well known, as is its widespread application within the petroleum industry for the determination of the molecular composition of complex mixtures. Few spectrometers have yet seen use in the chemical industry, and none, to my knowledge, except for one special application have been used on a process stream for continuous analysis and control.

Quality measurement of the future should find many process control spectrometers (Fig. 7) used in the continuous analysis recording and control of process stream composition. The process control spectrometer uses a multipoint recorder, which will record any reasonable number of points, or mass concentrations at predetermined mass numbers. A synchronously driven timing switch sets the accelerating voltage (a fixed magnetic field has been used) at a series of fixed values which correspond to specific preset masses to be recorded. As each mass is surveyed, the multi-point recorder is reconnected and will give the same type of record as a multi-point temperature recorder. The main application of the process control spectrometer to date has been

in the monitoring of small quantities and concentrations of gas to determine that their concentration remains the same; it has not been applied for the major components, i.e. large percentages, of the gas stream. The present design allows resolution of masses 29 and 30, but may be used where resolution is not required up to 400.

In passing, a series of analysis methods should be mentioned which involve a measurement of physical characteristics of the gas stream, such as its resonant frequency, combustibility, density, and thermal conductivity, but which measurement is a summation of the characteristics of each component. These methods as instrumented are not true analyzers, in that a total characteristic is measured, and analysis is only possible by the user having a complete knowledge of the gas composition data showing the variations in the gas composition with changing process conditions, such as when the fuel-air ratio changes in combustion gas. These methods are generally satisfactory when one component has a measurable physical characteristic widely different from those of the other components, and until an unexpected impurity enters the process stream; in the latter case a change in composition is indicated, but it cannot be interpreted either qualitatively or quantitatively as in spectroscopy.

A continuous flow pressure-type refractometer, originally developed for butadiene purity measurement, has been given the first of two steps necessary to convert a laboratory device to a quality measuring instrument for process control. Step one allows a continuous flow of material to be measured, but the measurement is manual based upon visual observation instead of being automatic.

A dipping prism is mounted in a pressure cell through which the liquid flows continuously at process pressure, while maintained at constant temperature. Observations are made visually through an eyepiece and the refractive index is then read from a calibrated dial which sets the prism at the position corresponding to the refractive index of the flowing stream. Six different prisms are available for various ranges. The instrument includes a constant temperature bath and a constant flow device to serve in place of a pressure regulator.

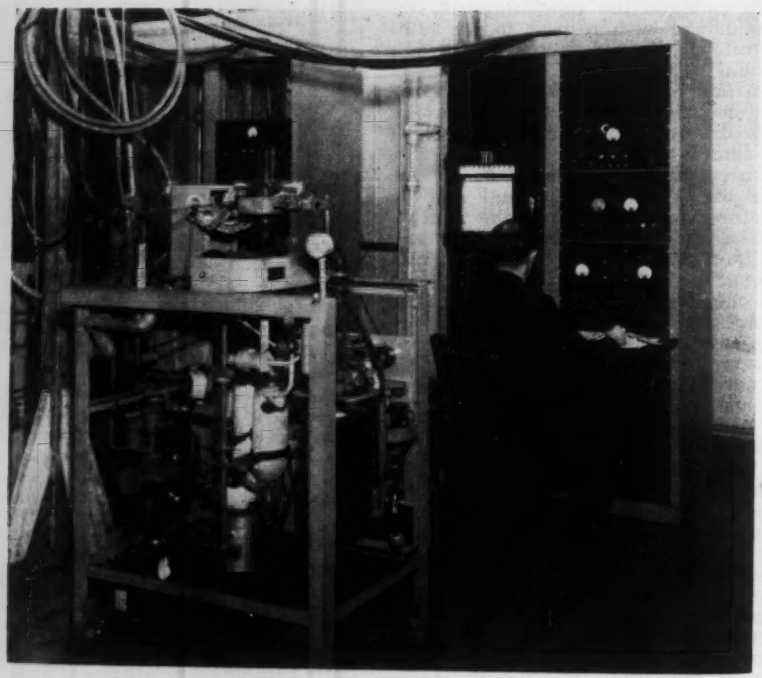


Fig. 7. G-E Process Control Spectrometer shown in test.

The refractometer is especially useful for determining the composition of finished products from stills, evaparators, and other equipment producing nearly pure liquids. Accuracy depends primarily on the composition of the liquid, and is improved with increase in accuracy.

Conclusion

The methods and devices that have been described represent only a small share of the quality measuring devices in use today. They are presented to show both a trend and an availability of certain tools. The measurement of quality alone is not the solution to any processor's problems. The determination of what "condition" variables should be controlled, and how to control them, remain. It is this field which we shall hear much of in the years ahead.

Let us depart from the field of flowing process streams to the field of human affairs and governmental policies supposedly based upon the desires of the majority of our voters. Let us designate all of our supposed audience as the quality to be measured, the quality being that of their attitudes and impressions of any particular phase of human affairs. Then let us consider the process as an integration of their individual thoughts, and the control as their action based upon this measurement of quality, or *opinion*. The Opion Meter (Fig. 8) is a quality me

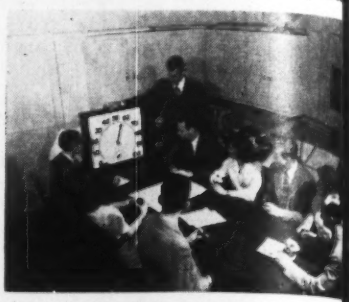


Fig. 8. "Opinion" Meter with small audie

uring tool of the first order, a tool be used for process control by definition here presented. We go haps from the tangible measureme to the intangible, but we see that strumentation now has a greater cha than ever before to play a potent in the greatest engineering field of human engineering.

Acknowledgment is made of the h of the many General Electric engine who have developed some of th equipments. Thanks go also to M. Behar who provided many helpful s gestions and criticisms.

Editor's Notes

(Continued from Page 757)

poration in Gary, and Central Scient Company in Chicago. Pre-registration necessary for all trips so that transpor tion can be arranged for well in adva of the starting time.

3. Conference Program Supplemen

Elsewhere in this issue of Instrumen will be found the complete program for Second Annual Instrument Conference Exhibit at the Stevens Hotel in Chic next month. Because of the arrangem whereby the Journal is a section of Inst ments magazine, it has been possible avoid duplication of effort and material this issue on matters pertaining to Conference by concentrating all such terial in the program supplement. He for full particulars on the Conference Exhibit, refer to the 1947 Conference P gram Supplement.

4. I.S.A. Sections Map

We have received many requests recen to publish a map showing the locations the various Sections of the Society. C sequently, we have prepared such a showing all present Sections and, in par thesis, the group or groups which h applied for and/or will receive Sect Charters at the Chicago Conference n month. With everyone headed for Chic within a couple of weeks or so after this published, we feel that the publishing this map is particularly appropriate at t time.

5. Erratum

In the "Who's Who" article on Al Sper in the July issue of the Journal, a typ graphical error put Al in the Consulti business while he was still in high scho While the statement may be true, consid ing Al's propensities, the fact is that 1917 in the third paragraph should h been 1937. Your pardon, please.

6. The Needle Points to—

Aruba, Gulf Coast, Oak Ridge, Philad phia, St. Louis, Southern Michigan a Tennessee—for (1) reports, and for good reports.

—R. R. Proc

What The Process Groups Expect Of Instrumentation"

By C. J. GRIFFIN†

(An Abstract)

comparing the typical refinery of fifteen or twenty years ago with odern unit, that is, one that has designed in the past five years, finds the difference to be astound- The same contrast is found in a parison of the instrumentation ap- on units of the same periods. In ain instances process developments ed the development of improved in- mentation, while in other cases de- pments in instrumentation per- ed improvements in processing; , it can be said that *they both have e a long way together.*

OWLEDGE OF PROCESS OPERATIONS

appraising the operation of a unit n the viewpoint of successful func- ing of the INSTRUMENTATION, *much ends on the interest, coöperation and iative of the Instrument Group.*

The knowledge of process operations t would be desired in the members an Instrument Group varies with type of unit. In general, it can be d that this is largely dependent on complexity of the operation, the ree of instrumentation on the unit cerned, and the age of the process.

In the case of new processes, this wledge becomes even more impor- t as it would be too much to expect at the original instrument design uld be completely satisfactory. When iginal design is not satisfactory it ans that a revision of the design is essary to obtain the desired operat- results. In some cases this may an minor modifications to the instru- nts originally provided, while in er cases a different type or series instruments may be necessary. A od illustration is the instrumentation oblems encountered when the Fluid talyst Cracking units were built dur- the war.

To arrive at a decision regarding what ange is necessary generally requires e collaboration of the Process and In- rument Groups. Sometimes this deci- n is not reached until after the fail- e of prolonged attempts to make the iginal installation work. *If the In- rument man had an intimate knowl- ge of the process, he could possibly cognize sooner the unsuitability of e instrument and be in a better posi- n to recommend the proper changes correct the installation.*

In many of the newer operations such Isomerization, Alkylation, and Cat- ytic Cracking, the processes are de- ndent on a recirculation operation. nowledge of recycle operations and e time lag involved in an operation this nature would undoubtedly sim- plify the job of synchronizing the instrumentation. The *accuracy* required of instrument installations *varies from the finest possible degree to a rather wide range.* A knowledge of the operation is the only method of determining this factor!

COOPERATION OF INSTRUMENT AND PROCESS GROUPS

A great many changes and refinements in Instrumentation can best be developed through collaboration of the Instrument and Process men *in the field.* It is realized that for the most part the Instrument Department's responsibilities are limited to minor changes, adaptations and/or relocations of existing equipment once the installation is engineered, but there is still much that can be done in this field.

To obtain the most satisfactory results from any installation it is necessary that its performance be followed very much the same as the progress of a patient is followed by the doctor. It is believed that this is a point that is often overlooked; in other words, *too often the instruments are attended to only when they are inoperable.*

Another point of importance is the case of troublesome instruments, that is, instruments that will not function any longer than a few days or a week without becoming inaccurate or inoperable. Full investigation of possible changes, both major and minor, in the arrangement may make the installation satisfactory for a long period of time and at the same time *reduce maintenance costs considerably.*

In all work of this nature *initiative plays an extremely important part.* The outstanding Instrument man will take the time to thoroughly investigate an installation from the viewpoint of "How can this installation be further improved?"

The outstanding man will familiarize himself sufficiently with the process to find out where an additional or improved instrument can be used profitably.

MEETINGS—MAINTENANCE PROBLEMS—NEW DESIGN

In general, more satisfactory results and better understanding result from occasional meetings between Instrument and Process men wherein both sides air their difficulties and problems, the end result being a better knowledge of each others' problems. It has been noted that *more frequently than not good results are obtained* from these occasional meetings.

In connection with the design of the Instrumentation for a new unit it is felt that considerable start-up difficulties could be avoided and better overall design would result if the preliminary design were reviewed by all parties concerned. That is, a joint meeting of the Instrument Maintenance, Instrument Engineering, Process Control, Design, and Operating Groups *should be held before the final design is approved.*

PRIDE IN WORK

It is believed that each man should feel that his particular job is just as important in the over-all results as anyone else's. When a unit is performing as perfectly as possible, a share of the pride in that performance is rightly his. When a unit is not functioning properly, each one connected with the source of trouble should make all possible efforts to correct the difficulty.

NEED FOR INSTRUMENTATION

With the advent of each new process, the necessity for adequate instrument installations becomes more and more important. No one will deny that *it would be practically impossible to operate most modern units without modern temperature, pressure and flow control instruments.* If the precise operations required could be controlled manually, the size of the operating crew required would make the cost of most operations prohibitive.

In connection with post-war business in a competitive market, all industry is becoming cost-conscious. In examining possible methods of cost reduction, one of the most fertile fields is the reduction in manpower by installation of automatic equipment.

NEW PROCESSES AND NEW CONTROL TECHNIQUES

The principle of conducting catalytic operations with the catalyst in a fluid state is a comparatively new process known to most of us in the form of a catalytic cracking unit. This same principle of conducting catalytic reactions with a solid catalyst in the fluid state is being developed for other catalytic processes besides cracking of petroleum. In this connection a part of the Instrumentation now being used on the Catalytic Cracking Unit is far from satisfactory and provides a field for wide development.

The following are items which offer a field for improved installation:

An instrument to determine *exact* location of levels of catalyst in Reactor and Regenerator from the exterior of these vessels without having to make calculations of catalyst density;

Further development of infra-red absorption recorders for measurement of components of Regenerator flue gases for improved control of regeneration of the catalyst;

Accurate and reliable recorders for measurement of small percentages of hydrogen in tail gases for indication of catalyst contamination;

Improved oxygen recorders for flue gases;

Development of improved instruments for catalyst-bearing streams that will eliminate immersion in streams and complicated blowback installations.

CONTROL PANEL LAYOUT

Some of the things visualized in Instrumentation of the units of the future are as follows:

Flow plan type of control board layout;

All temperatures, pressures and levels indicated at the proper points on the flow plan;

Automatic control at proper points with pushbutton remote operation as required;

†Assistant Division Superintendent in arge of the Catalytic Department, Aruba efinery, Aruba, N.W.I.

*Presented before the Aruba Section of e Instrument Society of America, Aruba, etherlands West Indies, July 1, 1947.

NOTE: Statements and opinions advanced papers are to be understood as individual pressions of their authors and not those the Society.

All emergency facilities with push-button operation on control board flow plan, including pushbutton stop and start, control of pumps, etc.;

All control board instruments of comparatively miniature size to permit a neat, concise layout.

Where a float control is subject to fouling, a special type of instrument is needed which can be mounted on the side of a vessel in which the level is to be controlled but which has no actual contact with the liquid.

Relationship of Instrumentation to Laboratory Control

Process operations today are still largely dependent on laboratory testing for control purposes. This introduces a time lag of several hours or a day between the time samples are obtained, analyzed, the results evaluated and changes made.

When instruments can be devised to automatically and continuously analyze the various streams on the units, a large savings will result from improved yields and product quality. In addition, products produced will in all probability meet improved specifications and will therefore have a greater value.

General News

Niagara Frontier Section Organized in May

By Russell Milham
Correspondent Pro Tem

The latent and extensive demand for the formation of a society dedicated to the enhancement of the arts and sciences of instrumentation and automatic control design, maintenance and application has recently been fulfilled in the Buffalo and Niagara Falls area.

This heavily industrialized area has a concentration of widely diversified industries including steel, chemical, oil refining, aircraft, rubber, food, plastics, resins, paper, ceramics, light and heavy equipment manufacturing. Instruments have played an ever-increasing part in the process control and measurement of all of the companies representing these industries in this area.

Millard D. Shriver, Buffalo Resident Engineer for the Bristol Company, was the "spark plug" in organizing the section. Shriver has been associated with the Bristol Company for four years, most of which time has been spent in the Buffalo area. During the early part of the war he organized and set up the Instrument Department of the Keystone Ordnance Works. For several years prior to that he was Instrument Engineer for the Carborundum Company in Niagara Falls. His initiation into the field instruments was at the Republic Steel Company's Meter Department. By nature and experience an organizer, Shriver provided the impetus to bring together the instrument-minded men in this area, and his efforts to form the Niagara Frontier Section were completely successful.

Seventy representatives of the aforementioned industries met on May 28, 1947 at the New York State Institute of Applied Arts and Sciences for the initial organizational meeting.

A presentation was given by Shriver of the aims and achievements of the Instrument Society of America. The necessity for a local section, whose aims and objectives coincided with the national group and the present and long range requirements of the represented industries was clearly demonstrated by the formation of the section and the election of the officers.

The name "Niagara Frontier Section of the Instrument Society of America" was established. The group voted to make application for charter to the national body and expects that the charter will be conferred at the National Conference in Chicago in September.

Constitution, membership, program, educational and employment committees were formed and immediately went into operation. A business meeting and discussion period concerning pertinent problems ensued. The various committees were instructed by the executive committee to carefully develop their individual programs, and the membership voted to hold the second meeting on June 23, 1947.

Dr. Richard R. Dry, Director of the New York State Institute of Applied Arts and Sciences, offered the use of the physical and educational facilities of the Institute, stressing the importance of the part the newly formed section would play in the correlation of the educational facilities of the educational and industrial activity of the area.

The following is a roster of the elected pro tem officers:

President—Clarence Boltz, National Aniline Division of Allied Chemical and Dye Corporation;

Executive Vice-President — Joseph Hildyard, Hooker Electrochemical Company;

Vice-President and Secretary — Kenneth J. Fees, The Carborundum Company;

Treasurer — Howard H. Fox, Buflovak Equipment Division of Blaw-Knox Corporation.

Correspondent—Russell Milham.

Foreign Visitors To Be Honored at Conference

The International Liaison Committee of the Second Instrument Conference and Exhibit has extended invitations to engineers of all countries to attend the Conference and Exhibit at the Stevens Hotel in Chicago, September 8-12, 1947.

Arrangements are being made with the Stevens Hotel so that foreign visitors arriving in Chicago before the Conference and remaining for a short time after the Conference can have the use of their hotel rooms during the whole period of their stay.

A reception room (Room 22, Stevens Hotel) will be provided so that the foreign visitors can make it their headquarters during the Conference. The International Liaison Committee has made arrangements to insure that foreign visitors will have a pleasant and profitable trip. The Committee expects to provide the service of interpreters and information service facilities. Specially conducted tours of the exhibits will be arranged.

A luncheon is scheduled for Wednesday, September 10, in honor of the foreign visitors, at which they will be the guests of the Chicago Section of the Society. All foreign visitors should make it a point to register with the committee as soon as possible so that they will receive invitations to the luncheon.

The chairman of the committee is Mr. J. B. McMahon, national Vice-President and member of the Executive Committee of the Chicago Section.

Texas A. & M. Offers Annual Instrumentation Short Course

On August 27, 28 and 29, 1947, the A. and M. College of Texas will hold its second annual Short Course on "Instrumentation for the Process Industries." The talks will be presented by outstanding men, and will be directed toward all engineers whose work requires a knowledge of industrial instrumentation; that is, toward instrument engineers, design engineers, process and operating engineers.

The course will be held on the campus, at College Station, Texas; all interested persons are invited to attend. The College will be glad to answer inquiries and encourages pre-registration by mail.

This series of courses is designed to lead to an improved understanding of the principles and practice of instrumentation as applied to the continuous fluid-flow process industries. The material will be on a practical engineering level. Theory, when it is needed, will largely be given non-mathematically.

The field as indicated by the title is so broad that it cannot all be covered adequately in any one year, according to a preliminary announcement recently released. The 1947 session will be devoted mainly to discussions of the basic considerations involved in instrumentation system design and actual examples of plant systems employing these principles. Some general economic and organizational features of process instrumentation will be presented, and in order that those who attend may be informed of recent developments in the instrument field, a talk describing some of the newer instruments and their uses will be given. The Friday afternoon Question and Answer period will provide a forum for the free interchange of ideas, and is expected to be most valuable.

It is intended that the Course will be useful to men in all types of continuous fluid-flow plants. It is believed that the industry will benefit by a knowledge of methods used in other industries; therefore, no attempt will be made to maintain an exact balance between the industries in any one year, but in the long run this will be done. This year the program will cover aspects of instrumentation as applied in both the petroleum and chemicals fields but the emphasis will be slightly stronger on the latter.

A printed bulletin covering the proceedings of the Course will be published after the sessions, and will be distributed free to the registrants. The registration fee for the three-day course is $5.00 per person; this is exclusive of the cost of the banquet and dinner, for which there will be extra charges. Rooms in the College dormitory at $1.50 per night, will be available.

Besides the exhibits, which are to be displayed during at least two periods each day, some of the papers and speakers scheduled are: *"Economics of Instrumentation in the Process Industries,"* by Dr. M. Blair, Carbide & Carbon Chemicals Corp., Texas City, Texas; *"Functions and Responsibilities of a Plant Instrument Department,"* by J. G. Kerley, Shell Oil Company, Inc., New York, N. Y.; *"Coordinating Process Control Systems and Some Unusual 'Angles' Dealing with their Usage and Components,"* by F. H. Trapnell, E. duPont deNemours & Co., Wilmington, Del.; *"Instrumentation for Speed Control,"* by J. G. Wilson, Shell Development Co., San Francisco, Calif.; *"Instrument Work in an Atomic Energy Laboratory,"* by U. Fisher, Monsanto Chemical Co., Dayton, Ohio; *"Instrumenting a Continuous Process,"* by H. C. Frost, Corn Products Refining Co., Argo, Ill.; *"Sea Water Bromine Process Chemical Control Systems,"* by Porter Hart, Dow Chemical Co., Freeport, Texas; *"The Instrumentation of a Hydroformer,"* by R. H. Koehler, Pan American Refining Corp., Texas City, Texas; *"Instrumentation of Cycling Plants,"* by A. J. Hutchinson, The Fish Engineering Corp., Houston, Texas; *"Instrumenting Physical Methods of Chemical Analysis,"* by Nels Gildersleeve, General Electric Co., Schenectady, N. Y.

Anyone desiring to register by mail should give his name, address and company affiliation, and enclose $5.00. The nights for which housing accommodations are required should also be stated. Further information concerning registration or details of the Short Course may be obtained by communicating with Mr. P. G. Murdock, Department of Chemical Engineering, Agricultural and Mechanical College of Texas, College Station, Texas.

Official News

To All Section Secretaries

To the many changes already in effect in the official list of Section Secretaries, Delegates and JOURNAL Correspondents, one more can be added this month, as follows:

SOUTHERN MICHIGAN SECTION: New Delegate—Ken Mead of Allen Electric Company, home address 1919 Buena Vista, Kalamazoo, Michigan; New Secretary and JOURNAL Correspondent—Robert J. Schoenfield of Western Michigan College, home address 203 E. Hammond, Otsego, Michigan.

AL BUSINESS MEETING OF SOCIETY DULED FOR 4:30 P. M., SEPT. 8, 1947

members of the Society are invited end the Annual Business Meeting of ociety scheduled for 4:30 p. m. on y, September 8, the opening day of cond Annual Instrument Conference Exhibit which is to be held at the s Hotel in Chicago. Installation of fficers and the annual reports of the ent, Executive Secretary, and Treas- re the principal items on the agenda. eeting will be held in the North Ball of the Stevens.

Y VOTING AT BOARD IRECTORS' MEETING

Board of Directors will hold a meet- n Saturday, September 6, 1947, in e Dining Room, at the Stevens Hotel icago for the purpose of electing officers ransacting other official business. Nat- it is to the advantage of each Section represented at this meeting by its of- Delegate or accredited alternate, the of which may be any duly authorized er of the Section. A letter authorizing lternate to act for the Section, and by the President or Delegate of the n, will serve as proper credentials if are requested at the meeting.

those Sections which may not have entatives at this meeting, it is sug- that their votes be cast by proxy. er or telegram authorizing some des- d person to act for the Section should nt to the Secretary of the Society or e person so designated. In this manner tions of and by the Board of Directors e truly representative of the wishes e entire membership of the Society. It ed that the total voting strength of ociety can thus be mustered at the ng on September 6th. The meeting is uled to start at 2 p. m.

Section News

ARUBA

r twelfth meeting was held on July 1st e Engineers' Club Building, the meeting called to order by President Art Mutt at 7:25 p.m. Following a short ess meeting, President MacNutt turned eeting over to Program Chairman Bill es, who introduced the speaker of the ng, Mr. C. J. Griffin, Assistant Division intendent in charge of the Catalytic rtment of the Aruba Refinery.

Griffin's talk was entitled "Refinery umentation" and was based on the em of "What Process Groups Expect trumentation." His talk was indicative hat the alert, progressive Operations intendent is concerned with in this noving age of new developments. In elief that Mr. Griffin's talk carries a ge of interest to every member of the , we are submitting an abstract of the for publication in the *Journal*. (ED. Thanks. Abstract appears elsewhere s issue.—RRP).

llowing Mr. Griffin's talk, considerable ssion ensued on the question of "where an Instrument Department rightly be- in the organization of any industry— the Engineering Department or under rocess Department?" The consensus of n was that it should rightly be under rocess Department.

9:30 the meeting was adjourned to the shments counter where hot coffee, wiches and home-made cream puffs enjoyed along with further discussion the lines suggested by Mr. Griffin's ble talk. —JIM LOPEZ, *Corr.*

GULF COAST

e regular monthly meeting of the Gulf Section was held on July 1, 1947. dent T. H. Pierson introduced the ker, Mr. Lyle E. Eige, Assistant Service ger of the Fisher Governor Company arshalltown, Iowa.

Eige presented a paper entitled n Facts Concerning Diaphragm Motor Valves, Their Design and Construction." He discussed methods of testing and results obtained in valve stem forces, explaining in some detail a new method of strain gage testing used at the Fisher plant. Projected slides illustrated the lecture.

The members and visitors enjoyed refreshments furnished by the Fisher Governor Company after the lecture.

—A. E. BUNN, *Sec'y-Treas.*

OAK RIDGE

The regular July 1st meeting of the Oak Ridge Section was a forum session featuring three members of the Section as speakers. The business meeting following the dinner concluded with the announcement that the nominating committee would present their list of nominations for the elective officers of the Section at the next meeting. The speakers for the evening were thn introduced by J. R. Mahoney and President A. V. Novak.

P. S. Buckley, Instrument Engineer at the Oak Ridge Clinton Laboratories of Monsanto Chemical Company, spoke first on "Gimmicks." He described the operation and design of several electrical and electronic devices used in chemical processes and laboratory work, including a circuit for calibration of electric flowmeters, a phototube relay circuit, and a circuit employing liquid level probes in conducting liquids used for actuating an indicator, lamp, buzzer and valve. An especially interesting gimmick described was an electronic solenoid controller employing the waves of a mercury pool and wire probe as an oscillator for controlling the pressure in a laboratory glass tube system.

The second speaker was G. R. Jamieson of Carbide and Carbon Chemical Corporation K-25 Plant. Mr. Jamieson discussed the use of the capillary in flow calculations. The general equation for calculating the flow of both gases and liquids through a capillary was given, and the derivation of the equation was discussed briefly with the aid of printed notes which were distributed to all present. Several sample problems were discussed and solved.

D. M. Boyd, also of Monsanto Chemical Company (Clinton Laboratories), was the last speaker, his talk covering the new "Foxboro D-C Dynalog." He described the instrument as a temperature indicator employing an electronic circuit and a variable condenser positioned by a reversible electric motor, the position of the condenser rotor being determined by, and indicative of, the thermocouple voltage being measured.

The forum type of meeting was proven a success and more of the same type are being planned for the future.

The August meeting will feature a talk and demonstration of "Induction and Dielectric Heating" by a representative of the Westinghouse Electric Corporation. Th September meeting will feature a talk by Mr. D. H. Fuller of the Foxboro Company on "Electronic Measuring Instruments for Process Applications."

—CHAS. W. COVEY, *Corr.*

PHILADELPHIA

The 48th meeting of the Philadelphia Section was held on June 18th at the Penn Sheraton Hotel. The meeting opened with announcements concerning the I.S.A. Annual Dance to be held at Whitemarsh Country Club on June 27.

This meeting was an especially enjoyable one, with a Gadget Contest, an excellent guest speaker, and a social half hour with refreshments.

Mr. Edwin Kremer of the Pennsylvania Industrial Chemical Company conducted the Gadget Contest and described the winning gadgets before awarding the cash prizes. As one would imagine, a gadget contest in an instrument group was a regular Hay Day and brought forth many phenomenal gadgets and applications. Those winning cash awards were:

W. Repsher, Pennsylvania Industrial Chemical Co., "Level Controller on Pitch Flaker;"

Frank Malinsky, Socony Vacuum Oil Co., "Electronic Impulse Generator for Timer Operation;"

Werner Young, Barrett Division, Allied Chemical, "Orifice Flow Meter Without Pressure Taps;"

A. Keeler, Socony Vacuum Oil Co., "Flow Measurement of Clay on a Conveyor Belt;"

Jack Johnston, E. I. duPont de Nemours, "Water Tank Level Controller."

First Prize went to Hugh L. McCulley of Atlantic Refining Company for his "Caustic Foam Level Control." The Aruba Section submitted several papers for the contest, one of which won a cash prize.

There were many items of interest on the honorable mention list, one of the most fascinating of the group being an automatic coffee pot, designed by Mr. J. Maguire. The description of this would require a separate technical paper, which is certainly out of the question in this report!

The guest speaker of the evening, Mr. Walter L. Lawrence of the RCA Victor Division, Radio Corporation of America, was introduced by President Ehly. Mr. Lawrence gave a talk on television and what makes it work, presenting it in such a clear manner that most of the members should even be able to tell their wives how it operates.

Mr. Lawrence's talk covered the television camera, methods of transmission, receiving units, industrial applications, educational applications (especially in the field of medicine), economic applications (advertising, etc.), entertainment applications, new applications and practically all fields where television has been successfully applied.

A very enthusiastic question period followed the talk, at which time Mr. Lawrence very ably answered all technical and general questions.

Everyone enjoyed the social get-together and refreshments after the meeting.

—C. B. PETTY, *Acting Corr.*

ST. LOUIS

The regular May meeting of the I.S.A. St. Louis Section was held in the Ballroom of the Hotel York in St. Louis on Monday, May 26. Total attendance was 85, with 60 attending the dinner.

The prizes in the Papers Contest were awarded: first prize of $10 going to Mr. Justin E. Stein of the Brown Instrument Company for his paper on a recent installation by his firm, and $5 second prize going to Mr. W. C. Collins of the Claude S. Gordon Company for his humorous exposition on instrumentation.

The program for the evening consisted of food, drink, fun and frolic. The regular dinner was preceded by a cocktail hour, and was followed by a program of entertainment including songs, dances, acrobatics and magic. The formal entertainment was followed by refreshments and community singing.

All those attending enjoyed a pleasant and convivial evening as the closing session of the season.

—H. E. ZEFFREN, *Corr.*

SOUTHERN MICHIGAN

Fifty-two members and guests of the Southern Michigan Section attended the last meeting of the season on June 18th at Chicken Charlie's in Kalamazoo. This being the annual meeting of the Section, a business meeting preceded the speaker of the evening. The Treasurer's report was read and approved. For the first year, we ended up with a goodly-sized bank balance.

The following officers were unanimously elected to serve for the coming season of 1947-48.

President—Oliver Woods, The Upjohn Company.

Vice-President and Delegate—Ken Mead, Allen Electric.

Secretary and JOURNAL Correspondent —R. J. Schofield, Western Michigan College.

Treasurer — Leon Simkins, Wiggington Company.

The speaker of the evening was Professor Clark of the University of Illinois, who presented a most interesting discussion of "New Instrumental Chemistry." Professor Clark pointed out that although the old classical methods are still taught and used

Southern Michigan Section Officers for 1947-48
Left to right: Simkins (Treas.), Woods (Pres.), Schofield (Sec.), Mead (V. P. and Delegate).

widely in analytical and quantitative analysis, methods are changing more and more to the use of instrumentation for this work, the petroleum industry being one of the leaders in this new field.

Using slides for illustration, Mr. Clark discussed briefly the instruments used in the fields of Micro-spectrometry, Infra-red Spectroscopy, and X-Ray Diffraction. He confined the major portion of his discussion to the advances and uses of X-Rays in the last fifty years since their discovery. Special attention was given to the trends in the use of X-Ray, such as analysis by X-Ray, such as analysis by X-Ray diffraction, etc.

Considerable discussion followed the talk and as the meeting adjourned, small groups formed and the discussions continued until the restaurant employees started to put the chairs on the tables and sweep the floor.

North American Phillips furnished an exhibit of an R-meter, Diffraction Cameras and Powder Cameras, which also attracted considerable attention after the talk.

Our next meeting will be in September, probably around the 17th.

—KEN MEAD, *Corr.*

TENNESSEE

The Tennessee Section held its June meeting as an annual outing at the Tennessee Eastman cabin grounds on June 21. Members' families and guests were invited.

The serving line formed at 6:30 p. m. and recreation for all followed. The outing was well received by all and with the interest shown in the past year we are looking forward to a larger and better coming year.

The June meeting is the last scheduled meeting until September. Plans are being made to present a diversified program in the fall.

—L. W. THAYER, *Sec'y*

Who's Who in the I. S. A.

HARVEY L. LEE

(Delegate, Cleveland Section)

Cleveland's Delegate, Harvey Lee, is one of the old-timers in Instrument Society work, although that was probably the furthest from his mind in his undergraduate days. After leaving Carnegie Institute of Technology in 1920 with all the intentions in the world of being a metallurgist, he started out with the Toledo Scale Company in Toledo, Ohio, to equip a physical and chemical laboratory. In purchasing equipment for this laboratory, Harvey became familiar with the Rockwell Hardness Tester and soon thereafter joined the Wilson Maeulen Company to help put this instrument on the market.

After travelling through New York, Pennsylvania, Ohio and Indiana for 18 months, Harvey was permanently situated in Pittsburgh as District Manager, and from that time on he spent most of his time on Pyrometer Sales and Engineering.

In 1932 Wilson Maeulen Company sold their pyrometer business to the Foxboro Company, and Harvey, along with about 30 other employees, went along with Foxboro. He stayed in Pittsburgh until March of 1945, when he was transferred to Cleveland as District Manager, which position he now holds.

Harvey was present at one of the first Instrument Society meetings in Pittsburgh about 10 years ago. He was more or less active in the Pittsburgh group, and following his transfer to Cleveland he became interested in the Cleveland Instrument Society. He was immediately put on the Membership and Program committees, and in May of 1946 was made chairman of the Membership committee and National Delegate. Although arrangements were not completed until September of 1946, Cleveland joined the I.S.A. as a Charter Section with fifty-some members, largely through the efforts of Harvey Lee. During his year as Membership chairman, he helped the Section increase its membership 120% — to 116 members!

In 1924 Harvey was married to Helen Ryan of Toleda. The Lees have one daughter, Nancy Ann, who is at present attending Flora Stone Mather College of Western Reserve University. Hobbies, Harvey says, are golf and collecting U. S. coins. Since locating in Cleveland he has dropped golf but still spends some of his spare time on his collection of coins. His greatest outside interest, however, is promoting the Instrument Society of America and working for a larger and better Cleveland Section.

WILLIAM G. BROMBACHER

(Chairman, Subcommittee—of Recommended Practices Committee—on Manometers Tables)

One of the first projects undertaken by the Recommended Practices Committee was the preparation of a set of accurate Manometer Tables for distribution to the members of I.S.A. When the subcommittee to handle this project was established, Dr. Wm. G. Brombacher of the National Bureau of Standards was appointed chairman.

Dr. Brombacher was born on Feb. 23, 1891. His formal education was undertaken at Wake Forest College, from which he obtained his B.A. degree in 1915 and his M.A. in 1917. His Ph.D. (in physics) was granted by Johns Hopkins University in 1922.

Since 1926, Dr. Brombacher has been Chief of the Aeronautic Instruments Section of the National Bureau of Standards, Washington, D. C. (On July 1st of this year the name of this section was changed to the Mechanical Instruments Section. ED.)

Dr. Brombacher was active in the organization of the Instrument Society of America, as well as in the Washington Section for several years, and is currently the President of that Section.

Married in 1920, the Brombachers have two daughters, Nancy J. and Mary. Nancy finished college in 1944, and Mary (now Mary Bieri) is attending Antioch College at the present time.

According to Dr. Brombacher, the work of the subcommittee on Manometer Tables is coming along slowly but surely, and it is hoped that some of the material already compiled will be ready for reproduction and distribution before long. This work seems to be Dr. Brombacher's chief hobby at present, his other hobbies being, as he says, "of wide interest but too plebian to put into print."

ISA EMPLOYMENT SERVICE

Forward your letter to INSTRUMENT SOCIETY OF AMERICA 1117 Wolfendale St., Pittsburgh 12, Pa.

INSTRUMENT MECHANICS with a minimum of three years experience on installation, maintenance of industrial instruments and control devices by the manufacturing department of a large oil company. Applicants should be high school graduates, 25 to 40 years of age. Rate $1.82½ per hour for forty hours per week. Retirement Plan, Sickness and Disability Benefits Plan, Vacation Plan, Group Life Insurance, Death Benefits for Annuitants. Location Missouri. Box 68.

* * *

INSTRUMENT MEN for the National Advisory Committee for Aeronautics at Langley Field, Virginia. Positions open are Instrument Mechanic, Electronic Mechanic, Glass Technician, Electrical Engineer, Mechanical Engineer. Salaries at Civil Service levels based on 40-hour week with 26 days annual leave and 15 days sick leave per year. Box 69.

* * *

INSTRUMENT SALES ENGINEERS by manufacturer of industrial control instruments. Five-year industrial experience required. Should be familiar with electronic instruments or have some radio experience. Location District Sales Office, Northern Ohio, Box 70.

* * *

INSTRUMENT ENGINEER to take charge of instrument department of medium-sized, progressive chemical company located in Pittsburgh, Pa. Must be experienced with various types of instruments, able to direct instrument service men and capable of specifiying instruments for various applications. Box 71.

* * *

INSTRUMENT MECHANIC by large petroleum manufacturer to service automatic boiler controls, recorders, flow meters; temperature recorders on dryers, cooking kettles and ovens. Must be able to make efficiency checks throughout plant. Salary $250.00 per month. Location Southern Illinois. Box 72.

THE EMPLOYMENT REGISTER

The Employment Committee will conduct an Employment Register at the Second Annual Instrument Conference and Exhibit, Hotel Sherman, Chicago, Illinois, September 8-12, for the benefit of those instrument men seeking employment and of the employers of instrument men seeking qualified applicants.

A file of applicants will be available for review of bonafide prospective employers having open positions.

A file of open positions will be available for the review of registered applicants.

Interested instrument men and prospective employers are urged to register by mail with the Employment Committee prior to the opening of the Conference and Exhibit.

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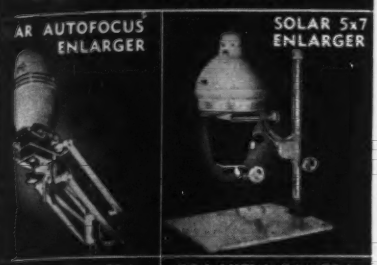

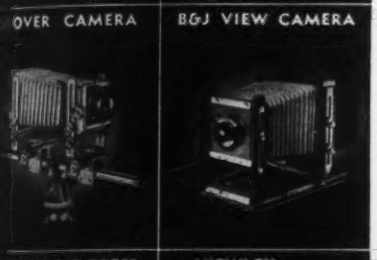

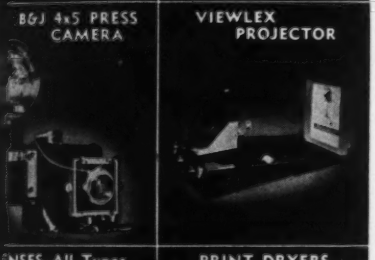

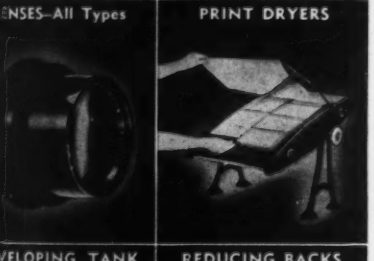

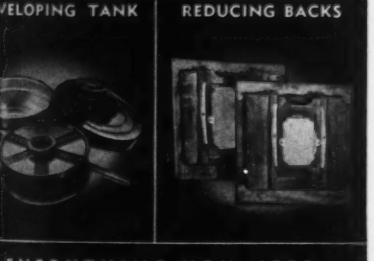

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Manufacturers' New Literature

In this department we report new literature pertaining to instrumentation, received from the manufacturers. We urge readers to request ONLY those bulletins which will be of value to them. Use the Postage-free Order Card below.

O-403 **Capacitors.** 16-page 8½" × 11" Catalog No. 76 pictures and describes the maker's line of paper, mica and silvered mica capacitors for the electronic industry. Sangamo Electric Co., Springfield, Ill.

O-404 **Testing Equipment and Panel Instruments.** 24-page 8½" × 11" Catalog No. 447 illustrates and describes maker's line of testing equipment and panel instruments for AM and FM radio communications, television and for industrial and scientific maintenance. Supreme Instruments Corp., Greenwood, Miss.

O-405 **High-vacuum Distillation.** 16-page 8½" × 11" booklet contains an illustrated description of the process of molecular distillation, as well as maker's laboratory distillation. Distillation Products, Inc., 755 Ridge Rd. West, Rochester 13, N. Y.

O-406 **"Faxfilm Fax."** 2-page 8½" × 11" Vol. I, No. 4 of this house organ discusses: surface roughness vs. surface conditions, plating problems, machining research and set-up. Includes current price and delivery schedule. The Faxfilm Co., 1220 W. 6th St., Cleveland 13, Ohio.

O-407 **Circuit Protection.** 8½" × 10" Catalog No. 9 (first issue in five years) pictures and discusses maker's line of fuses, fuse mounting, neon indicators, circuit testers, etc. Littlefuse Inc., 4757 Ravenswood Ave., Chicago 40, Ill.

O-408 **Process Program Controllers.** 2-page 8½" × 11" Circular No. 211 gives instructions for adjustment and operation of "CMR" and "CMS" Cyclo-Monitors. Counter and Control Corp., 2737 S. 28th St., Milwaukee, Wis.

O-409 **"The Laboratory."** 36-page 6"×9" Vol. 17, No. 1 of this house organ reviews a number of the leading chemical, biological and metallurgical publications. Also presented is an article on the Oscilloscope with accompanying pictures and diagrams. Fisher Scientific Co., 717 Forbes St., Pittsburgh, Pa.

O-410 **Voltage Control.** 12-page 8½" × 11" Bulletin 547 pictures and describes "Powerstat" line of variable transformers and the "Stabiline" voltage regulator products. The Superior Electric Co., 303 Laurel St., Bristol, Conn.

O-411 **Combustion Control.** 4-page 10½" × 7¾" Bulletin 1022 illustrates and discusses maker's systems of combustion control for spreader stoker-fired boilers. Result charts also shown. Bailey Meter Co., 1050 Ivanhoe Rd., Cleveland, Ohio.

O-412 **Mass Spectrometer.** 18-page 8½" × 11" booklet includes pictures, diagrams and description of Consolidated Mass Spectrometer Model 21-102 pointing out its applications and methods of analysis, also gives details of the instrument's work capacity, service and special features. Consolidated Engineering Corp., 620 N. Lake Ave., Pasadena 4, Calif.

O-413 **Fuel Injection Test Equipment.** 8-page 8½" × 11" booklet presents diagrams and descriptions of pressure indicators, pump-calibrating and governor-regulating test stands, spray-test apparatus, accessories and service equipment. Ferrier Engineering, 185 Breckwood Blvd., Springfield, Mass.

O-414 **Area Meter.** 4-page 7¾" × 10½" Bulletin 233 explains how the maker's new area-type fluid meter measures fluid flow and totalizes flows through two or more lines. Bailey Meter Co., 1050 Ivanhoe Rd., Cleveland 10, Ohio.

O-415 **Automatic Control for Gas Industry.** 16-page 8½" × 11" Bulletin 135 illustrates and describes various control systems for stack draft, furnace pressure and exhauster controls for single or parallel operations. Included too are gas mixing systems by straight volumetric and correction methods. Askania Regulator Co., 240 E. Ontario St., Chicago 11, Ill.

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Instruments, 1117 Wolfendale St., Pittsburgh, Pa. *(August 1947)*

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